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(1). Casson, An Introduction to Victorian  
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A precise definition of iron architecture is almost impossible. As it was used in the 19th century it referred to the use of iron in a building as its major structural and constructional material and in the use of the material where it had a radical influence on the appearance of the building. I have followed this general meaning and therefore have excluded from my list many buildings which have other examples of ornamental ironwork that were added to buildings in addition engineering structures, such as bridges, vias, and lighthouses, have not been included unless they had a direct effect on the use of iron in architecture.

Because of the vast number of examples of iron buildings the text refers only to those that directly contributed to the essential development of iron architecture. It soon became apparent that in a survey of iron architecture, because of the diversity of examples and the many parallel developments, a strictly chronological one could not be followed. Therefore I have decided to list the major examples

"Ignorance, it has been said, is a prerequisite of the historian. This is particularly true of anyone who attempts to survey, however superficially, the achievements of the nineteenth century. The material at his hand is so overwhelming in bulk and so bewildering in texture and colour, that all he can do is pick over the tumbled debris of this vast quarry, and select at random a few stones which, when held up to the light, may reveal something of the nature of the complex mass from which they came."

(H. Casson, An Introduction to Victorian Architecture, 1948).

A precise definition of iron architecture is almost impossible. As it was used in the 19th century it referred to the use of iron in a building as its major structural and constructional material and to the use of the material where it had a radical influence on the appearance of the building. I have followed this general meaning and therefore have excluded from the study iron balconies, railings, gates, and other examples of ornamental ironwork that were added to buildings. In addition engineering structures, such as bridges, piers, and lighthouses, have not been included unless they had a direct effect on the use of iron in architecture.

Because of the vast number of examples of iron buildings the text refers only to those that directly contributed to the essential development of iron architecture. It soon became apparent that in a survey of iron architecture, because of the diversity of examples and the many parallel developments, a strictly chronological sequence could not be followed. I therefore decided to list all the major examples

of iron architecture in chronological order in an appendix. (Appendix I). In this appendix I have not repeated lists of buildings that can be found in other books. Included in this category are iron fronts in New York<sup>1</sup>, Liverpool<sup>2</sup>, and Glasgow<sup>3</sup> and iron railway stations.<sup>4</sup>

As little recent research had been done on the 'portable building' a large part of my study was concentrated on this subject. It soon became obvious that the work of Andrew Handyside of Derby was of particular interest in this field and I was persuaded to publish a paper on their work separately.<sup>5</sup> (Bound in as Appendix II).

I have not, therefore, included this material in the main body of the thesis and have only referred to it where the text demanded.

The major departure from a generally chronological account was the decision to single out, for reasons of clarity, the account of the contribution of iron to the development of a new style of architecture.

Because many of the buildings examined in the thesis may be unfamiliar, I thought it sensible to include a rather large number of plates. This has had the beneficial effect of being able to reduce the length of descriptions of these buildings and to simplify the

<sup>1</sup> D. Badger, Illustrations of Iron Architecture, New York, 1865, pp. 11-35.

<sup>2</sup> Quentin Hughes, Seaport, 1964, Chapter IV.

<sup>3</sup> Andor Gomme and David Walker, Architecture of Glasgow, 1968, pp. 116-7.

<sup>4</sup> Carroll L. V. Meeks, The Railway Station, 1957.

<sup>5</sup> M. Higgs, The Exported Iron Buildings of Andrew Handyside and Co. of Derby, Journal of the Society of Architectural Historians, May 1970, pp. 175-80.

technical explanations that were necessary. In addition much of the illustrated material is only available in 19th century books, pamphlets and journals, many of which are scarce and therefore difficult to consult.

A number of people who provided valuable information. Among these I should particularly like to mention Dr. E. Greene Robertson of Melbourne who continues a busy medical practice with extensive research on Iron buildings in Australia. I should also like to thank Mr. Sharad K. Mehta of the Indian Institute of Architects who provided valuable information on Iron buildings in Bombay. In addition Mr. José García-Bryce of Lima unearthed the fascinating story of Bellhouse's Custom House at Paita after it was completed.

Among those who showed kind passages and gave much time, I should like to thank the librarians of the Avery Library, Columbia University, New York; Local History Library, Derby; R. L. S. A. Library, London; Mitchell and Commercial Libraries, Glasgow; and of course the University Library and the National Library in Edinburgh.

\* An R. L. S. A. research award and a grant from the University of Edinburgh did allow me to make a visit in 1960 to New York to pursue research on the iron-iron bridge in America.

## ACKNOWLEDGEMENTS

As an extensive tour abroad<sup>\*</sup> to pursue research on exported 'portable buildings' proved impossible, I am particularly grateful to a number of people who provided valuable information. Among these I should particularly like to mention Dr. E. Graeme Robertson of Melbourne who combines a busy medical practice with tireless research on iron buildings in Australia. I should also like to thank Mr. Shamadi Y. Madan of the Indian Institute of Architects who provided valuable information on iron buildings in Bombay. In addition Mr. José García-Bryce of Lima unearthed the fascinating story of Bellhouse's Custom House at Paita after it was completed.

Among those who showed kind patience and gave much time, I should like to thank the librarians of the Avery Library, Columbia University, New York; Local History Library, Derby; R.I. B. A. Library, London; Mitchell and Commercial Libraries, Glasgow; and of course the University Library and the National Library in Edinburgh.

\* An R. I. B. A. research award and a grant from the University of Edinburgh did allow me to make a visit in 1966 to New York to pursue research on the cast iron front in America.

## LIST OF ABBREVIATIONS

- A.P.S.D.     The Dictionary of Architecture, edited by Wyatt Papworth for the Architectural Publication Society, 8 Vols., 1852-92.
- Colvin        H.M. Colvin, A Biographical Dictionary of English Architects (1660-1840), 1954.
- dem.          Demolished.
- R.I.B.A.      Royal Institute of British Architects.
- Ware          Dora Ware, A Short Dictionary of British Architects, 1947.

Chapter I

- 1) Iron capital and column. Plate 13 from Jean Tijou, A New Booke of Drawings, 1693.
- 2) The House of Commons (in St. Stephens) by Karl Anton Hickel, 1793. From the National Portrait Gallery, London.
- 3) The House of Commons (in St. Stephens) by Sir George Hayter, 1833. From the National Portrait Gallery, London.
- 4) A Capital for an Iron Support to Galleries &c. Plate CLXXXII from Batty Langley, The City and Country Builder's and Workman's Treasury of Designs, 1740.
- 5) Derby Mill, by William Strutt, 1792-3. From A. W. Skempton and H. R. Johnson, The First Iron Frames, Architectural Review, March 1962, pp.176-7.
- 6) Shrewsbury Mill, by Charles Bage, 1796-7. From A. W. Skempton and H. R. Johnson, op. cit., p.181.
- 7) Designs for Bridges, (1773-5) by Thomas F. Pritchard. From John White, Notice of Mr. Pritchard's Gradual Progress in the Application of Iron to the Erection of Bridges, The Philosophical Magazine and Annals of Philosophy (New Series), February 1832, Plate I.
- 8) The Iron Bridge at Coalbrookdale, by Thomas F. Pritchard and Abraham Darby, 1779. From a measured drawing by R. Maguire, P. Matthews and J. Benson in the Architectural Association Journal, July-August 1958.
- 9) Bridge Designs for St. Nevis by John Rennie, (a) 1791, (b) 1794. From J. G. James, Some Early Cast Iron Bridges, The Engineer, January 29th 1965. p.204.
- 10) Drawing from Roland Burdon's Patent for iron bridge construction, 18th September, 1795, (No.2066). From, The Repertory of Arts and Manufactures, Vol. V, 1796, Plate XX.
- 11) Bridge over the Wear at Sunderland, by Roland Burdon and Thomas Wilson, 1793-6. From Robert Stephenson, Iron Bridges, Encyclopaedia Britannica, 8th Edition, 1856, Vol. 18, p. 577.

- 12) Bridge over the Rio Cobre, Spanish Town, Jamaica, 1801.  
Photograph by G. Wolton, 1971.

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- 13) Ceiling plan from Samuel Wyatt's Patent No. 2410, 10th June 1800. From the Commercial Library, Glasgow.
- 14) Cross section from Samuel Wyatt's Patent No. 2410, 10th June 1800. From the Commercial Library, Glasgow.
- 15) Plan of the New Palace at Kew by James Wyatt, 1802-11. From Anthony Dale, James Wyatt, 1956, p.188.
- 16) Drawing from Ralph Dodd's Patent No. 3141, 3rd June 1808. From the Repertory of Arts and Manufactures, Vol. XIV, February 1809, p.145.
- 17) Theatre Royal, Plymouth by John Foulston, 1811-13. First Floor Plan. From John Foulston, The Public Buildings erected in the West of England, 1838, Plate 25.
- 18) Theatre Royal, Plymouth. Plan of Iron Work to Boxes and Corridors. From John Foulston, op.cit., Plate 41.
- 19) Theatre Royal, Plymouth. Cross section of Iron Work to Boxes and Corridors. From John Foulston, op.cit., Plate 42.
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- 21) Theatre Royal, Plymouth. Details of Iron Work to Boxes. From John Foulston, op.cit., Plate 44.
- 22) Theatre Royal, Plymouth. Iron Roof. From John Foulston, op.cit., Plate 45.
- 23) St. George's Everton, Liverpool, by Thomas Rickman and John Cragg, 1813-14. Interior view of ironwork to gallery and nave roofs. Photograph from the collection of the School of Architecture, Liverpool University.
- 24) St. George's Everton. Plan and long section. Measured drawing from the collection of the School of Architecture, Liverpool University.
- 25) Drawing from John Cragg's Patent No. 3761, 29th November 1813. From the Commercial Library, Glasgow.



- 26) St. Michael's in-the-Hamlet, Liverpool, by Thomas Rickman and John Cragg, 1814-15. Long section. Measured drawing from the collection of the School of Architecture, Liverpool University.
- 27) St. Michael's in-the-Hamlet. Interior view of the nave. Photograph from the collection of the School of Architecture, Liverpool University.
- 28) St. Michael's in-the-Hamlet. Exterior view of nave and aisles. Photograph by the Author.
- 29) St. Philip's Hardman Street, Liverpool, by Thomas Rickman and John Cragg, 1816. From Quentin Hughes, Seaport, 1964, p. 138.

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- 30) Design for a Pavilion and Greenhouse, Plas-Newydd, Anglesey, by Humphry Repton, before 1803. From Humphry Repton, The Landscape Gardening and Landscape Architecture of ... H.R., ed. by J. C. Loudon, 1840, p. 218.
- 31) Design for a Conservatory, Carlton House, London, by Humphry Repton, 1803. From the Royal Library, Windsor, (Topographical Catalogue 32, 17090, F. 15.)
- 32) Design for a Forcing House, by Sir G. S. Mackenzie, 1815. From the Transactions of the Horticultural Society of London, Vol. II, 1817, p. 170.
- 33) Curvilinear Hot-houses, Bayswater, by J. C. Loudon, 1818. From J. C. Loudon, Encyclopaedia of Gardening, 4th Edition, 1826, p. 315.
- 34) Orangery at Rochetts, Essex, designed and built by W. and D. Bailey, Holborn, before 1824. From (J. C. Loudon), The Greenhouse Companion, 1824, Fig. 6, p. 17.
- 35) Conservatory at Bretton Hall, Yorkshire, designed and built by W. and D. Bailey, 1827. From J. C. Loudon, An Encyclopaedia of Cottage, Farm and Villa Architecture, and Furniture, 1833, p. 980.

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- 36) Iron Roof, Hungerford Fish Market, by Charles Fowler, 1835. Plan and perspective. From Charles Fowler, Metal Roof at Hungerford Market, Transactions of the Institute of British Architects, Vol. I, 1836.

- 37) Iron Roof, Hungerford Fish Market. Details of Ironwork. From Charles Fowler, op. cit.
- 38) Train sheds, Euston, by Charles Fox, 1835-9. From J. Gloag and D. Bridgewater, A History of Cast Iron in Architecture, 1948, p. 48.
- 39) Great Stove, Chatsworth, by Joseph Paxton, 1836-40. From G. F. Chadwick, The Works of Sir Joseph Paxton, 1961, p. 84.
- 40) Palm Stove, Royal Botanic Gardens, Kew, by Richard Turner and Decimus Burton, 1844-7. From H. R. Hitchcock, Early Victorian Architecture in Britain, Vol. 2, Plate XV 31.
- 41) Palm Stove, Kew. Cross section. From Charles M'Intosh, The Book of the Garden, Vol. I, p. 120.
- 42) Palm Stove, Kew. Details of Ironwork. From Charles M'Intosh, op. cit., p. 120.
- 43) Palm Stove, Kew. Interior view. From H-R. Hitchcock, op. cit., Vol. 2, Plate XV 32.
- 44) Coal Exchange, London, by J. B. Bunning, 1846-9. From H-R. Hitchcock, op. cit., Plate X 14.
- 45) Coal Exchange, London. Ground floor stanchions. From H-R. Hitchcock, London Coal Exchange, Architectural Review, May 1947, p. 185.
- 46) Coal Exchange, London. Balcony Soffite. From H-R. Hitchcock, London Coal Exchange, Architectural Review, May 1947, p. 186.
- 47) Great Exhibition, 1851. Cover of the Official Descriptive and Illustrated Catalogue of the Great Exhibition, 1851.
- 48) Great Exhibition Building by Sir Joseph Paxton and Sir Charles Fox, 1851. Plan of ground floor and galleries. From the Official Descriptive Catalogue etc., facing p. 106.
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- 50) Great Exhibition Building. Detail of base plate to column. From M. D. Wyatt, The Construction of the Building, Official Descriptive Catalogue etc., p. 53.
- 51) Great Exhibition Building. Junction of typical column and truss. From M. D. Wyatt, op. cit., p. 54.

- 52) Great Exhibition Building. Typical truss of 24 feet span. From M. D. Wyatt, op. cit., p. 54.
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- 54) Great Exhibition Building. 'Paxton' gutter. From M. D. Wyatt, op. cit., p. 60.
- 55) Great Exhibition Building. Typical diagonal bracing. From Cyclopaedia of the Useful Arts, edited by Charles Tomlinson, 1854, Vol. 1, p. xxxviii.
- 56) Great Exhibition Building. Spindle moulding machine for the 'Paxton' gutter. From M. D. Wyatt, op. cit., p. 74.
- 57) Great Exhibition Building. Sash bar machine. From M. D. Wyatt, op. cit., p. 76.
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- 59) Great Exhibition Building. Glazing wagon. From Cyclopaedia of the Useful Arts etc., p. xliii.
- 60) Great Exhibition Building. Interior view from south entrance. From M. D. Wyatt, op. cit., facing p. 57.
- 61) University Museum, Oxford by Sir T. Deane and B. Woodward, 1855-68. Detail of iron capital in quadrangle. From C. L. Eastlake, A History of the Gothic Revival, 1872, p. 285.
- 62) University Museum, Oxford. View of quadrangle. From The Builder, June 23rd 1860, p. 399.
- 63) University Museum, Oxford. Wrought iron spandrils. From H. W. Acland and J. Ruskin, The Oxford Museum, 1859, p. 89.

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- 66) Royal Chapel, Buckingham Palace, by Edward Blore, 1842-3. From the Illustrated London News, April 8th 1843, p. 235.
- 67) Iron church for Jamaica, by Peter Thompson, 1844. From the Illustrated London News, September 28th 1844.
- 68) St. Paul's temporary (iron) Church, Kensington by Samuel Hemming and Co., 1855. From the Builder, October 27th 1855, p. 507.
- 69) The Ecclesiological Society's Iron Church, by William Slater, 1856. Plan. From Instrumenta Ecclesiastica, Second Series, 1856, Plate LXVII.
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- 74) Iron Church by Samuel Hemming and Co., 1862. Interior perspective view. From the Official Illustrated Catalogue of the International Exhibition, 1862, Volume II, p. 19.

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- 75) Corn Mill, Constantinople, by Sir William Fairbairn, 1839-42. Plan at first floor level, and cross section. From William Fairbairn, Treatise on Mills and Millwork, Vol. II, p. 121 and p. 122.
- 76) King Eyambo's Palace (Calabar) Nigeria, by William Laycock, 1843. From the Builder, 13th May 1843, p. 170.
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- 85) Messrs. Miller and Dinsmoor's Shop, Collins Street,  
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- 86) Iron cottage with handsome cast iron front, (Corio Villa)  
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- 87) 'Corio Villa', Geelong, Australia, by C. D. Young and Co., 1855,  
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- 88) 'Corio Villa', Geelong, Australia. Plan. From E. Graeme  
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- 89) Custom house, Payta, Peru, by E. T. Bellhouse, 1853-4.  
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- 90) Custom house, Payta, Peru. Elevation. From the Civil  
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- 94) Watson's Building, Bombay, by R.M. Ordish. From The Architect, December 11th 1869, p.286.
- 95) Watson's Building, Bombay. Photograph by Shamadi Y. Madan, 1970.
- 96) Watson's Building, Bombay. Details of ironwork. From The Architect, December 18th 1869, p.298.
- 97) Design for an Iron Church, 1910. From the Catalogue of W. Cooper Ltd., London.

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- 98) Cast iron factory, New York, by James Bogardus, 1848-9. From James Bogardus, Cast Iron Buildings, New York, 1856.
- 99) Cary Building, Chambers Street, New York, by Daniel Badger, before 1865. From Daniel D. Badger, Illustrations of Iron Architecture, New York, 1865, Plate VII.
- 100) Design for an iron store front, by William J. Fryer, 1870. From the Architectural Review and American Builders' Journal, February 1870, p.444.
- 101) Design for an iron store front, by William J. Fryer, 1870. From the Architectural Review and American Builders' Journal, March 1870, p.510.
- 102) Store front, Albany, N.Y., by Daniel Badger, before 1865. From Daniel D. Badger, op.cit., Plate XXI.
- 103) Design for an iron front for a dwelling house, by Daniel Badger, before 1865. From Daniel D. Badger, op.cit., Plate XIV.
- 104) Designs for store fronts, by Daniel Badger, before 1865. No.7, 61, Walker Street, New York. No.8, 53, Broadway, New York. From Daniel D. Badger, op.cit., Plate XV.
- 105) Iron front, 495, Broadway, New York, by Daniel Badger, (Architect, G.H. Johnson) before 1865. From Daniel D. Badger, op.cit., Plate XI.
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- 107) Collosseum Building, Jamaica Street, Glasgow, by H. Barclay and A. Watt, 1857. From the Building Chronicle, February 1st 1857.

- 108) Oriel Chambers, Liverpool, by Peter Ellis, 1864.  
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- 109) Oriel Chambers, Liverpool. Detail of bay window. Photograph  
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- 110) Iron front, Irongate, Derby by Owen Jones, 1872. From the  
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### Chapter VIII

- 111) Title page from William Vose Pickett, New System of  
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## ABSTRACT OF THESIS

Iron architecture had its origins in the use of iron columns in the early 18th century and this led to the achievement of a partially fireproof, internally-framed iron building in the closing years of the century. Parallel to this development the techniques of iron bridge building progressed rapidly in the twenty years following the building of the Coalbrookdale Bridge. During this period the principles of portability were evolved and successfully put into effect by the export of an iron bridge to Jamaica in 1801.

The shortage of timber during the Napoleonic Wars encouraged the use of iron, and, combined with the continuing search for fireproof buildings, led to the first true examples of iron architecture. One of the spectacular applications of cast iron at this time was the three churches in Liverpool designed by Thomas Rickman and John Cragg.

The substitution of iron for timber in glazing bars and the concept of circular hot-houses were factors which led to the establishment of ferro-vitreous architecture in the 1830's. The techniques of using iron and glass exactly fitted the demands of many of the new building types of the Victorian age - markets, railway termini, exchanges, museums and exhibition buildings. The Great Exhibition building was the most successful building of this type from both the technical and artistic points of view.

Church building employed iron firstly in temporary churches. The criticism of these led to the Ecclesiological Society's prototype iron church.



The cheapness and lightness of iron buildings greatly favoured their portability and this led to an extensive export trade in both corrugated and 'handsome' iron buildings. Some portable buildings were constructed from standard components and others were custom built and used the services of architects and engineers.

The prolific trade in cast iron fronts in America based on the imitation of stone architecture makes a vivid contrast to the equivalent fronts in Britain where a high degree of originality in design was achieved.

The introduction of iron had a significant effect on theoretical writing on architecture in the 19th century. Although the problem was recognised in the early years of the century, the first, and somewhat unsuccessful, attempt to describe a new style of architecture based on iron, was made by William Vose Pickett in 1845. Although no explicit style ever gained support, an implicit style, epitomised by the Great Exhibition building, can be seen as an underlying style for all iron buildings in the second half of the 19th century.

The appearance in 1692 of a plate showing an iron column in Jean Tijou's book of designs for ironwork<sup>1</sup> may be said to be the first evidence of iron employed as a structural material. (See Plate 1) John Harris<sup>2</sup> has shown that this was almost certainly the pattern used by Wren when he added galleries supported on columns to the House of Commons in 1706-7 to accommodate the influx of new British Members.

Although the capital in Tijou's book was probably intended to be in iron the capitals in the House of Commons were certainly in

## CHAPTER I <sup>designed by Gabriel Gibbon.</sup> (See Plates 2 and 3).

The search for fireproof construction and the development of iron fabrication techniques in bridge construction (1706-1801).

In 1740,<sup>3</sup> (See Plate 4). Significantly he describes it as a "capital for an iron support to Galleries and." He does not call it an iron capital and adds the idea that its purpose was to support a gallery. This surely suggests that he must have known the work done by Wren in the House of Commons.

<sup>1</sup> Jean Tijou, A New Book of Drawings, 1692, Plate 13. A facsimile edition of this work was published in 1930 with an introduction by J. Sturges Gardner. Selected plates including Plate 13 are included in J. Harris, English Decorative Ironwork from Contemporary Source Books (1510-1830), 1960.

<sup>2</sup> J. Harris, Cast Iron Columns, 1706, Architectural Review, July 1961, pp. 60-61.

<sup>3</sup> Ibid., p. 60.

<sup>4</sup> Henry Longley, The City and Country of Henry's and Workmen's Treasury of Designs, 1740. Plate CLXXXII.

The appearance in 1693 of a plate showing an iron column in Jean Tijou's book of designs for ironwork<sup>1</sup> may be said to be the first evidence of iron envisaged as a structural material. (See Plate 1) John Harris<sup>2</sup> has shown that this was almost certainly the pattern used by Wren when he added galleries supported on columns to the House of Commons in 1706-7 to accommodate the influx of new Scottish Members.

Although the capital in Tijou's book was probably intended to be in iron the capitals in the House of Commons were certainly in timber and carved by Grinling Gibbons.<sup>3</sup> (See Plates 2 and 3). Batty Langley reproduced the Tijou drawing with remarkable accuracy and without acknowledgement in his "Treasury of Designs" in 1740.<sup>4</sup> (See Plate 4). Significantly he describes it as a "capital for an Iron Support to Galleries etc." He does not call it an iron capital and adds the idea that its purpose was to support a gallery. This surely suggests that he must have known the work done by Wren in the House of Commons.

<sup>1</sup> Jean Tijou, A New Book of Drawings, 1693, Plate 13. A facsimile edition of this work was published in 1896 with an introduction by J. Starkie Gardner. Selected plates including Plate 13 are included in J. Harris, English Decorative Ironwork from Contemporary Source Books (1610-1836), 1960.

<sup>2</sup> J. Harris, Cast Iron Columns, 1706, Architectural Review, July 1961, pp. 60-61.

<sup>3</sup> Ibid., p. 60.

<sup>4</sup> Batty Langley, The City and Country Builder's and Workman's Treasury of Designs, 1740. Plate CLXXXII.

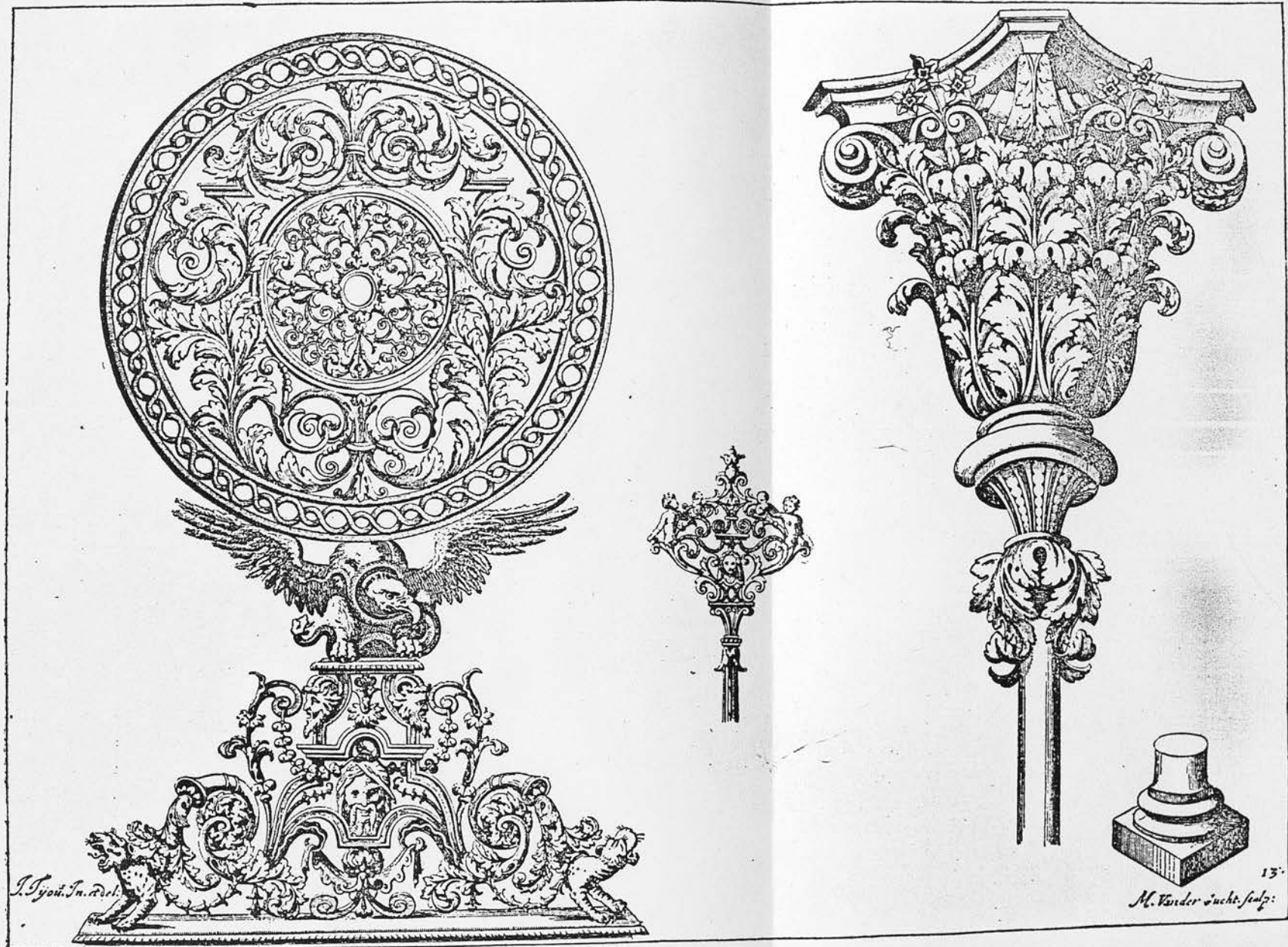


Plate 1. Iron capital and column, by Jean Tijou, 1693.



Plate 2. The House of Commons (in St. Stephens) by Karl Anton Hickel, 1793, showing Wren's alterations of 1706-7.

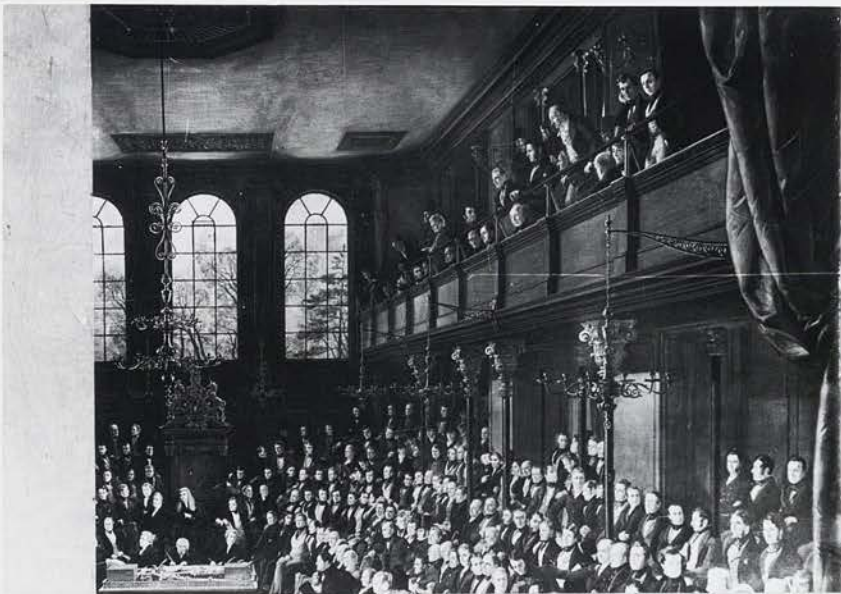
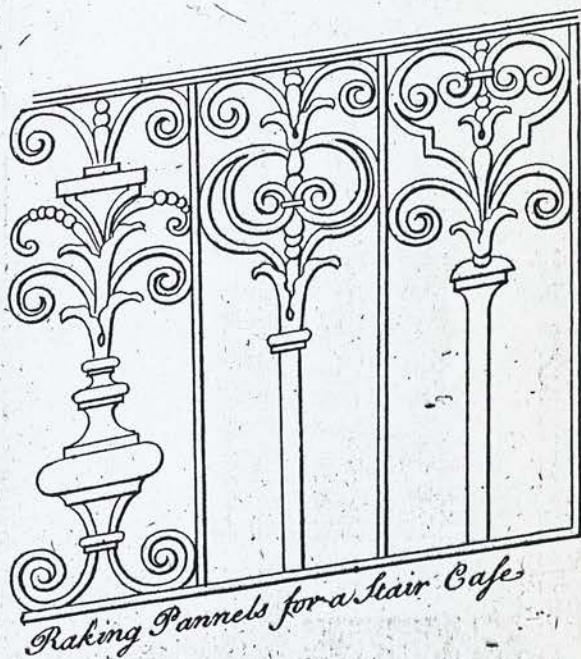
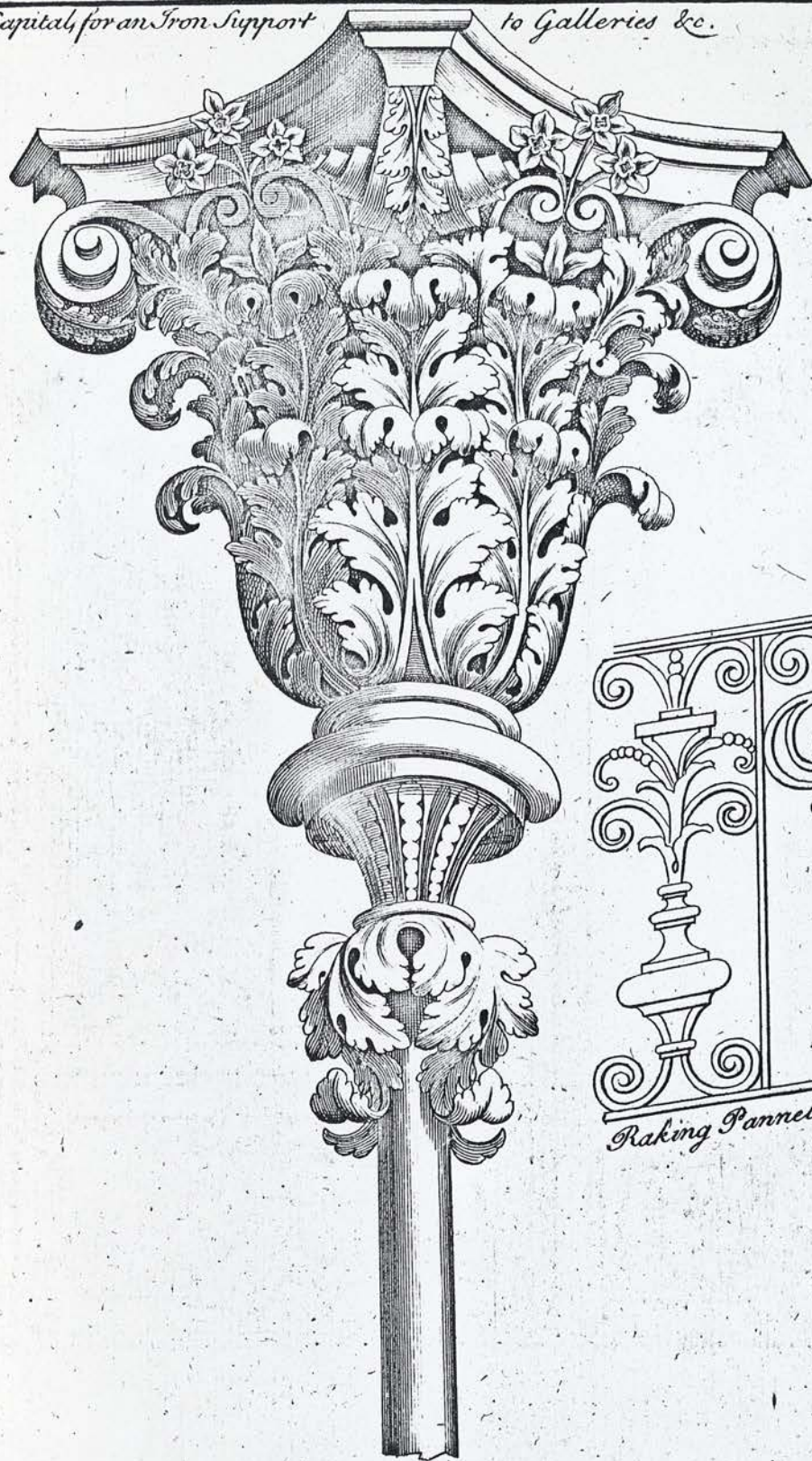


Plate 3. The House of Commons (in St. Stephens) by Sir George Hayter, 1833. The second line of iron columns was added by James Wyatt, c.1800.





*Raking Pannels for a Stair Case*

*The Langley Sculp.*

Plate 4. A Capital for an Iron Support to Galleries &c., by  
Batty Langley, 1740.

Not surprisingly, this is the first and only example.

Throughout the major part of the 18th century iron was an expensive material, and the planning requirement that Wren was faced with, that is to provide galleries to bear heavy loads and to minimise the obstructions of viewing on the floor below, were unlikely to recur frequently. The obvious buildings to reproduce these conditions were churches. But it was not until 1770 that we find iron columns used in St. Anne's, Liverpool<sup>5</sup> to support the gallery. Abraham Darby's successful smelting of iron with coke,<sup>6</sup> the development of the canal system and improvement of roads, and the use of steam power, promoted a rapid growth in the iron industry,<sup>7</sup> so that these columns represented nothing of the expense and achievement of workmanship that Wren's had 60 years or so before. In the remaining years of the 18th century we find several instances of similar use of iron structurally in churches.<sup>8</sup>

<sup>5</sup> The Stranger in Liverpool, 3rd edition, Liverpool, 1812, p.97.

<sup>6</sup> T.S. Ashton, Iron and Steel in the Industrial Revolution, 3rd edition, Manchester, 1963, p.28 ff.

<sup>7</sup> M.W. Flinn, An Economic and Social History of Britain since 1700, 1965, pp. 62-66.

<sup>8</sup> Quentin Hughes, Seaport, 1964, p.174, note 2. The following should be added to the list: St. James, Toxteth, Liverpool, 1774-5. See N. Pevsner, The Buildings of England, South Lancashire, 1969. Old Church, Lightcliffe, Yorkshire, 1774-5. See N. Pevsner, Pioneers of Modern Design, 1960, p.129. All Saints, Wellington, Shropshire, 1790, by G. Steuart. See N. Pevsner, The Buildings of England, Shropshire, 1958. Mr. Hughes was correct in excluding from his list Francis Hiorn's Church at Tetbury, 1777-81. See M. Whiffen, Stuart and Georgian Churches, 1947, p.76. I have inspected the cores of these columns and found them to be of oak. They do not support the roof structure but only the light timber and plaster vaulting.

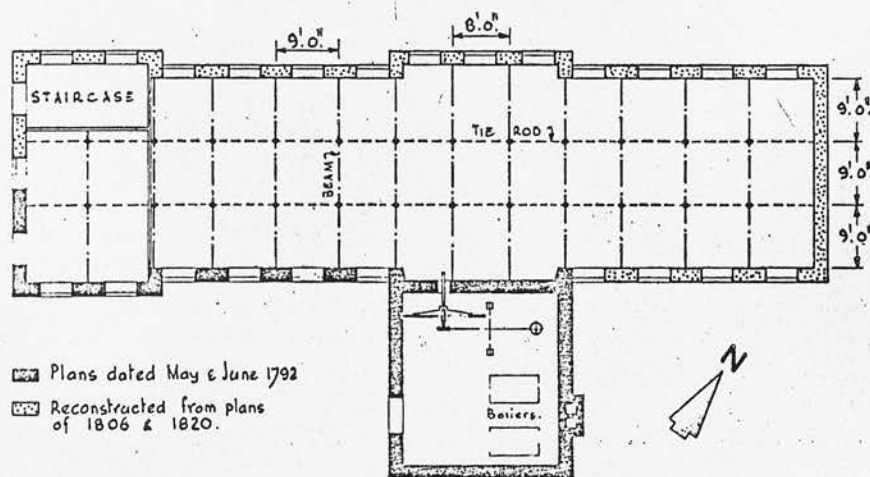
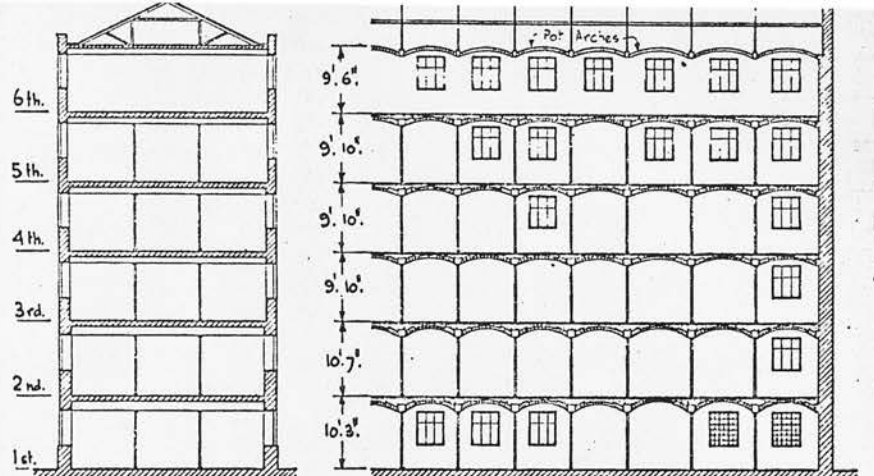


Further development, however, from the use of columns to the more extensive use of iron as a framing material is a story which entirely concerns the cotton industry, engineers and certain iron masters. It is too familiar a story to repeat and has been painstakingly explored by Bannister, Skempton, Johnson and Pacey.<sup>9</sup> What emerges from these studies is that, as a result of several disastrous fires in mill buildings in the 1780's and early 90's, the first mill with fireproof floors was designed by William Strutt and built in 1792-3. (See Plate 5). It consisted of a framework of iron columns with protected timber beams. Between the beams spanned arches of hollow earthenware pots with a sand filling below a tile floor. It took only four years for cast iron beams to be substituted for the timber beams in Benyon, Bage and Marshall's flax mill at Shrewsbury. (See Plate 6). At this point we have a multi-storey interior framed in iron, with fireproof floors.

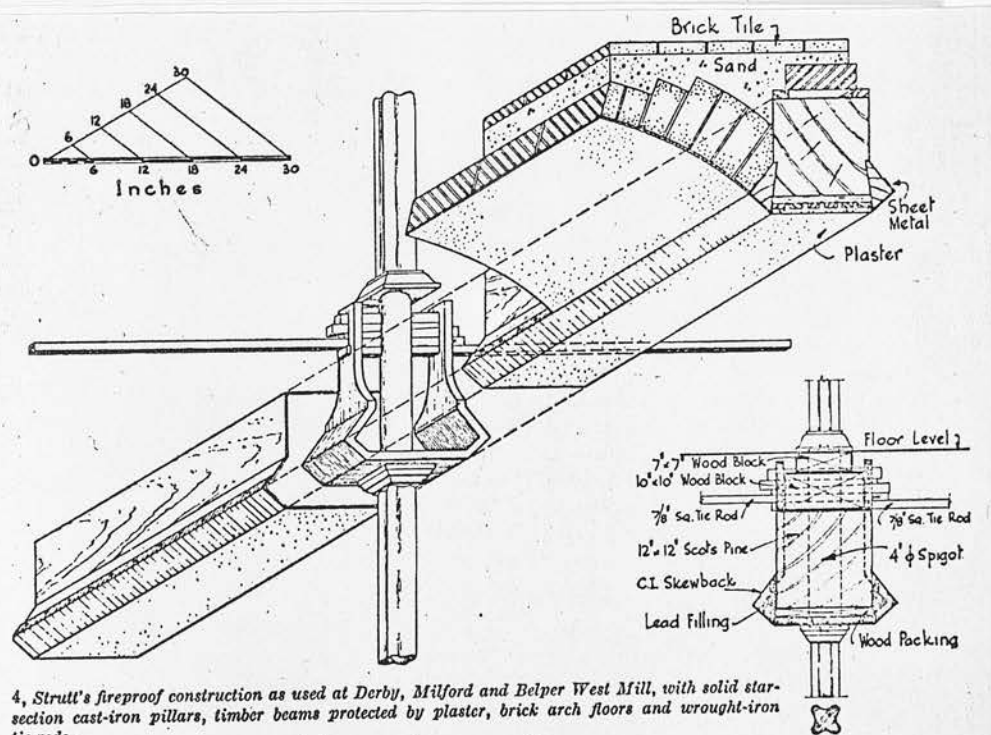
The search for fireproof construction in the last decade of the 19th century was not confined exclusively to the domain of industrial buildings. Early in 1793 the Association of Architects in London "took into consideration the causes of the frequent fires within the limit of the Act . . . . . for the further and better regulation of

<sup>9</sup> Turpin Bannister, The First Iron Framed Buildings, Architectural Review, April 1950, pp.231-46. A. W. Skempton and H. R. Johnson, William Strutt's Cotton Mills, 1793-1812, Transactions of the Newcomen Society, Volume 30, 1956, pp.179-205. A.W.Skempton and H.R. Johnson, The First Iron Frames, Architectural Review, March 1962, pp.175-86. A. J. Pacey, Earliest Cast Iron Beams, Architectural Review, February 1969, p.140.



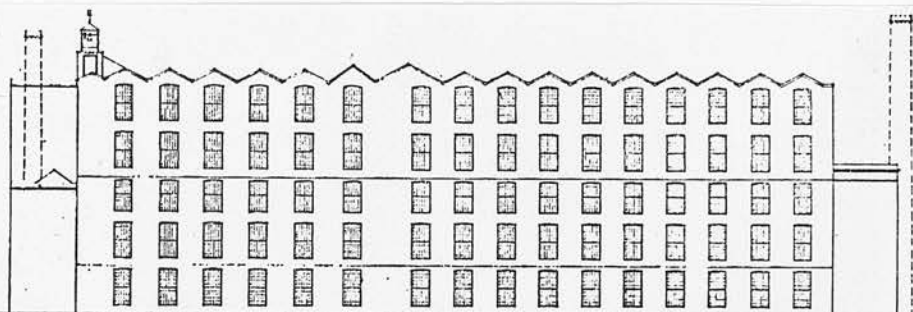


Plans dated May & June 1792  
Reconstructed from plans  
of 1806 & 1820.

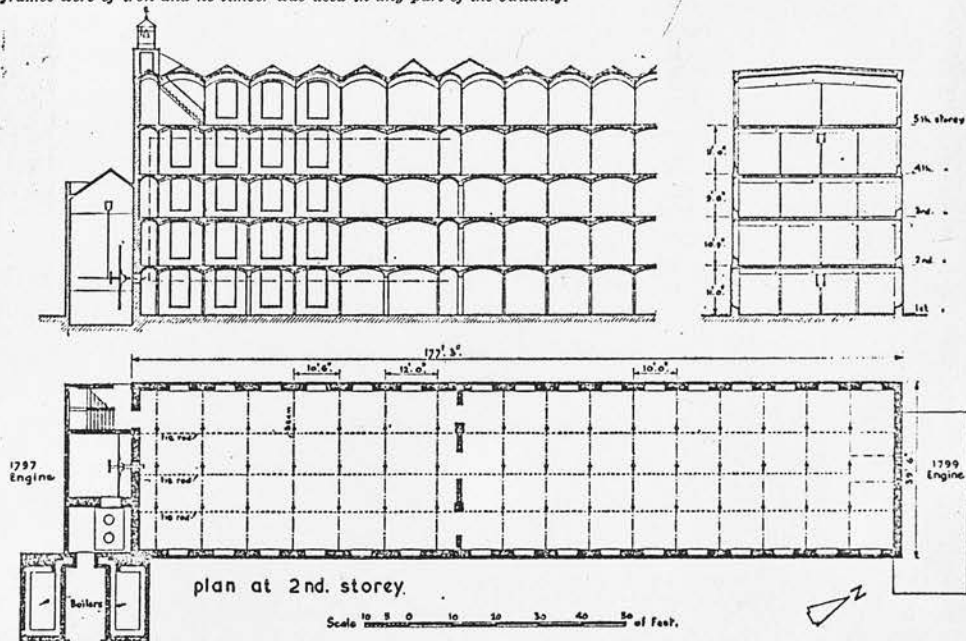


4, Strutt's fireproof construction as used at Derby, Milford and Belper West Mill, with solid star-section cast-iron pillars, timber beams protected by plaster, brick arch floors and wrought-iron tie rods.

Plate 5. Derby Mill, by William Strutt, 1792-3.



10, east elevation of the Shrewsbury mill as completed by Bage in 1707, with the north engine house of 1709. The window frames were of iron and no timber was used in any part of the building.



11, plan and section of Bage's Shrewsbury mill, 1700-07. It was the first multi-storey building with an interior iron framework. The walls are of brick.

Buildings and Party Walls etc., etc.; and the best means that can be adopted for preventing the like in future." Their report was published in 1793.<sup>10</sup> The committee, headed by Henry Holland, consisted of a very large number of the most distinguished architects of the day<sup>11</sup> including many that were to make significant contributions to the development of fireproof construction, and who used iron as an important element in their work, later in their careers. The report is largely concerned with domestic building and therefore with the design of party walls and fireproofing timber floors. There are two references to the use of iron. The first refers to tests done on two houses constructed with timber floors protected by Mr. Hartley's iron plates.<sup>12</sup> The second, more interestingly, refers to the use of iron for bretsummers and to James Peacock's book of villa plans published in 1785<sup>13</sup> under his pseudonym. Peacock refers to the "absurd custom of building upon breast summer fronts of timber", and suggests that "the superincumbent Wall should be erected upon Iron Cradles, bent into regular curves, which should

<sup>10</sup> Resolutions of the Associated Architects with the Report of a Committee by them appointed to consider the Causes of the frequent Fires and the best means of preventing the like in future, 1793.

<sup>11</sup> John Carr, Sir William Chambers, Samuel Cockerell, George Dance, Thomas Hardwick, John Soane, and James Wyatt.

<sup>12</sup> A full description of this construction is given in David Hartley, An Account of the Method of securing Buildings (and Ships) against Fire, 1774.

<sup>13</sup> (James Peacock,) "Oikidia" or Nutshells by J. MacPacke, 1785.

be secured at their bases or springings, by proper ties and abutments, and be supported by iron standards; the whole to be of wrought and even faggotted iron, but by no means of cast iron."<sup>14</sup>

This was a remarkable observation for Peacock to have made at this date. He recognised the problem of the brittleness of cast iron and its unpredictable behaviour in fire. The suggestion of wrought or faggotted<sup>15</sup> iron which is a far superior material took another 50 years to really be adopted as an alternative for cast iron, where it was subject to high tensile stresses and possible damage by fire.

Before examining the attempts by architects to introduce iron construction in a major way in the first decade of the 19th century, it is important to look at the development of the use of iron in bridge building in the last thirty years of the 18th century. During these years a sophisticated constructional vocabulary in iron was developed. It was also demonstrated that, by designing a bridge of small components, it could be easily exported.

Although attempts were made in France to construct an iron bridge in Lyons in 1755,<sup>16</sup> the first iron bridge in the western world to be successfully constructed was the bridge over the Severn near

<sup>14</sup> Ibid., p. 2.

<sup>15</sup> This almost certainly refers to annealed cast iron: a process which greatly increases the ductility of cast iron.

<sup>16</sup> E. M. Gauthey, Oeuvres: Traité de la Construction des Ponts, Paris, 1813, Vol. II, Book III.

Coalbrookdale completed in 1779. Authorship of this pioneer work is difficult to determine precisely. Three figures emerge as having made major contributions to its successful completion. They were Thomas Pritchard, the Shrewsbury architect and the famous iron-masters, Abraham Darby III and John Wilkinson. Pritchard produced a design for a masonry bridge with an iron centre in 1774 and in October of the next year a design fully exploiting cast iron.<sup>17</sup> (See Plate 7). The precedent is self evidently a timber bridge, but it is quite remarkable that Pritchard, a provincial architect, should have produced a design in 1775 which contained the germ of what Rennie, Telford and others were to apply so successfully twenty years or so later. Unfortunately this design was not built for two main reasons. In 1777<sup>18</sup> it was decided, firstly, to increase the clear height to 59 feet to allow the 'Severn trows'<sup>19</sup> to pass underneath and, secondly, to provide a towing path. In October of 1777

<sup>17</sup> John White, Notice of Mr. Pritchard's Gradual Progress in the Application of Iron to the Erection of Bridges. The Philosophical Magazine and Annals of Philosophy (New Series), February 1832, pp. 81-2.

White, who was Pritchard's grandson (Colvin p. 477 & 663) had the engravings made from Pritchard's original designs which were then in his possession. See T. Tredgold, A Practical Essay on the Strength of Cast Iron 4th Edition 1842-6, Part I, p. 10, Note 10. The original designs are now lost.

<sup>18</sup> Full details of minutes of the bridge committee on 14th July 1777 can be read in R. Maguire and P. Matthews, The Ironbridge at Coalbrookdale, Architectural Association Journal, July/August 1958, p. 34.

<sup>19</sup> A masted barge used on the Severn which was then navigable as far as Shrewsbury.



Plate 7. Designs for Bridges, (1773-5) by Thomas F. Pritchard.

Pritchard died, and so the alterations to the design were then in other hands. Who produced the final design we do not know.

Tredgold suggests Daniel Onions,<sup>20</sup> Smiles a Mr. Thomas Gregory.<sup>21</sup>

Both gentlemen may have been involved, but the energy, enthusiasm and not least, money, came principally from Abraham Darby with all the skill and knowledge of the great Coalbrookdale Foundry behind him, and John Wilkinson<sup>22</sup> of the Broseley Foundry. Casting of the members for the bridge took place during the winter of 1778-9, and erection took place during the summer of 1779, the bridge finally being opened for traffic on 1st January 1781.<sup>23</sup> The final design which was built could be said to have regressed from Pritchard's design of 1775. (See Plate 8). The bridge is "composed of five ribs; and each rib of three concentric rings or circles, which are

<sup>20</sup> T. Tredgold, op.cit. p.10.

<sup>21</sup> Samuel Smiles, Industrial Biography: Iron Workers and Tool Makers, 1879, p.91.

<sup>22</sup> Wilkinson, known as 'iron mad' Wilkinson, had been the first man to successfully construct an iron boat in 1787. See E. H. Knight, The Practical Dictionary of Mechanics n. d., Art. Iron Vessel, Vol. II, p.1205. He also erected at Bilston, Staffordshire, a chapel in which the pillars, windows, door frames and pulpit were in cast iron. See W. H. Chaloner, Early Iron 3. Notes on Wilkinson, Architectural Review, November 1949, p.333. His will directed that he should be buried in a cast iron coffin, and a cast iron obelisk was erected where he was buried, in Lindale, Lancashire. See J. Gloag and D. Bridgewater A History of Cast Iron in Architecture, 1948, p.64.

<sup>23</sup> Arthur Raistrick, Dynasty of Iron Founders, 1953, pp.197-9.

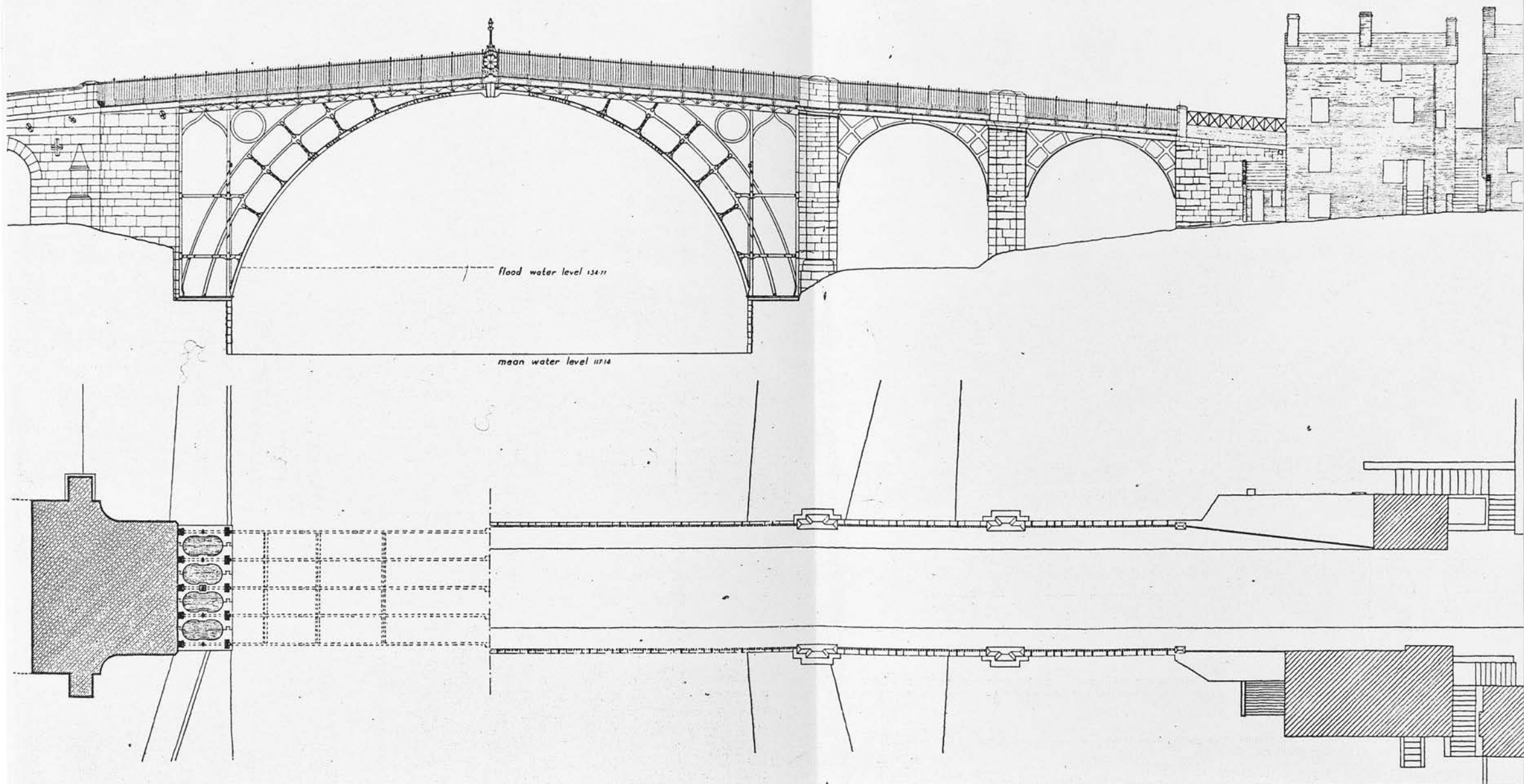


Plate 8. The Iron Bridge at Coalbrookdale, by Thomas F. Pritchard and Abraham Darby, 1779.



connected together by radiated pieces. The inner ring of each rib forms a complete semi-circle; the others only segments, being terminated and cut off at the road-way. These rings pass through an upright frame of iron, which stands on the same plate as the ribs spring from; which not only acts as a guide to the ribs, but also supports a part of the road-way. Between the inner upright of this frame and the outer ring of the ribs, in the haunches, is a circular ring of iron, of about 7 feet diameter; and between the outer upright of the frame, and the ribs, are two horizontal pieces, which act as abutments between the stonework and the ribs."<sup>24</sup>

Because of the height of the arch and abutments, the two side arches in timber framing were built about 1800 to lighten the abutment which was subsiding towards the river and crushing the original arch. The side arches were replaced in iron in 1820.

Although the building of the bridge was a technical tour-de-force, (the main ribs of 45 feet weighed 5 tons) the assembly details were crude and merely applied timber detailing to iron with mortices, wedges and screws used in profusion.<sup>25</sup>

Nevertheless the bridge immediately became a frequently visited and praised monument. "The River Severn, winding between high wooded hills opposite to the forge of Broseley, is crossed by

<sup>24</sup> Charles Hutton, Tracts on many interesting parts of the mathematical and philosophical sciences. 1812, Vol. I., Tract VI, p.145.

<sup>25</sup> Maguire, R. et al., op.cit. pp.39-41.

a bridge of one arch, 100 feet in length and formed entirely of cast iron with strong stone abutments, which presents at once a striking effect in landscape, and a stupendous specimen of the powers of mechanism."<sup>26</sup>

It was not until 1786 that iron bridges were to be developed further by the unlikely figure of Thomas Paine. Although born in England, Paine had become a naturalised American and it was in Bordentown, New York in 1786 that he worked on two models of bridges, one to be in timber the other in cast iron. The models have not survived, but we know that he was aiming at a long span single arch avoiding piers because of "the conditions of many of the rivers in America on account of the ice in the winter."<sup>27</sup> Later in the year he worked on a model of a single span iron arch of 400 feet for the Schuylkill as there was interest in the building of a bridge at that time (in masonry). Paine saw this as an opportunity to further his own ideas on iron bridges. However nothing was decided in favour of Paine's ideas by the time he left for France in 1787 bearing with him one of the models to present to the Academy of Sciences in Paris. This was done, and a special committee of

<sup>26</sup> Abraham Rees, Cyclopaedia or Universal Dictionary of Arts, Sciences and Literature, Vol. VIII, 1819, Art. Coalbrookdale.

<sup>27</sup> Letter to Benjamin Franklin, June 6th 1786 in (Philip S. Foner), Complete Writings of Thomas Paine, New York, 1945, p.1027.

the Academy was set up to examine his model and present a report. Their opinion was favourable and, consequently, Paine resolved to "ascertain the truth of the principle on a larger scale than could be shown by a portable model."<sup>28</sup> To this end Paine "went to the iron-foundry of Messrs. Walker of Rotherham, County of Yorkshire ... and had a complete rib of 90 feet span, and 5 feet of height from the chord line to the center of the arch, manufactured and erected."<sup>29</sup> The weight of the rib was three tons, and in a test it was successfully loaded with six tons of pig iron. Prior to this experiment Paine took out a patent<sup>30</sup> on his principles of iron construction. This is a most remarkable specification as it contains the first description of the cardinal principles of portable structures. He states, "Among the advantages of this construction is that of rendering the construction of bridges into a portable manufacture, as the bars and parts of which it is composed need not be longer or larger than is convenient to be stored in a vessel, boat or wagon, and that with as much compactness as iron or timber is transported to or from Great Britain; and a bridge of any extent upon this construction may be manufactured in Great Britain and sent to any part of the world to be erected."

<sup>28</sup> Thomas Paine, Memoir to the Congress of the United States on the Construction of Iron Bridges, in (Foner), op. cit. p. 1052.

<sup>29</sup> Ibid, p. 1052.

<sup>30</sup> No. 1667, 26th August 1788. Constructing arches, vaulted roofs and ceilings, either in iron or wood.

Paine, after the success of his experimental rib was to put to test his principles of portable bridge design. He "entered into an agreement with the iron-founders at Rotherham to cast and manufacture a complete bridge to be composed of five ribs of 210<sup>31</sup> feet span, and 5 feet of height from the chord line, being a segment of a circle 610 feet diameter, and sent it to London to be erected as a specimen for establishing a manufactory of iron bridges to be sent to any part of the world."<sup>32</sup>

The bridge arrived by ship in London in the spring of 1790, and was erected on Leasing-Green (now Paddington Green) by the summer. It attracted many visitors at a shilling each and favourable press notices. By October, however, Peter Whiteside, an American merchant in London who had jointly financed this venture, went bankrupt. Paine, however, managed to raise money to pay Whiteside's share of the venture and the bridge stayed on exhibition. After being on show for a year it was dismantled and taken back to the Rotherham foundry.

In November 1790 Edmund Burke's 'Reflections on the Revolution in France' was published. "This work by Mr. Burke" says Paine, "absurd in its principles and outrageous in its manner, drew me . . . . from my bridge operations."<sup>33</sup>

<sup>31</sup> Two other letters from Paine give the span as 110 feet. See (Philip S. Foner), op. cit., p. 1294 and p. 1303.

<sup>32</sup> Thomas Paine, Memoir etc., in (Philip S. Foner), op. cit. p. 1053

<sup>33</sup> Ibid. p. 1053.

From that time Paine worked eagerly to refute Burke. As a consequence the 'Rights of Man' was published in 1791. The next year he left for France where he lived until 1803. He had little success thereafter with his bridge projects, neither the French nor the Americans were willing to adopt his ideas in practice.

It is something of a mystery why Paine should have produced such an original contribution to a field of enterprise which was so foreign to his normal literary and political activities. He did, however, write on a number of diverse scientific subjects, and from these it is apparent that he had a clear grasp of scientific method and perhaps his career as an inventor and engineer was simply overtaken by events.

It is most likely that the next person to experiment with iron bridges would have seen Paine's bridge at Paddington. This was John Rennie, who, in 1791 prepared a design for an iron bridge intended for the isle of Nevis in the Caribbean.<sup>34</sup> (See Plate 9). The design has several features in common with Paine's bridge - the shallow arch, the ribs made of small pieces, the transverse connectors between ribs. The only new feature was the haunches filled with circular rings of iron.

Work did not proceed on this design, but in 1793 the foundation stone was laid for a new iron bridge over the Wear at Sunderland. John Nash had produced a design for a masonry bridge in the previous year,<sup>35</sup> but this was rejected in favour of the iron bridge mainly on

<sup>34</sup> Charles Hutton, op. cit., p. 156.

<sup>35</sup> John Summerson, John Nash - Architect to King George IV, 2nd edition 1949, p. 44.

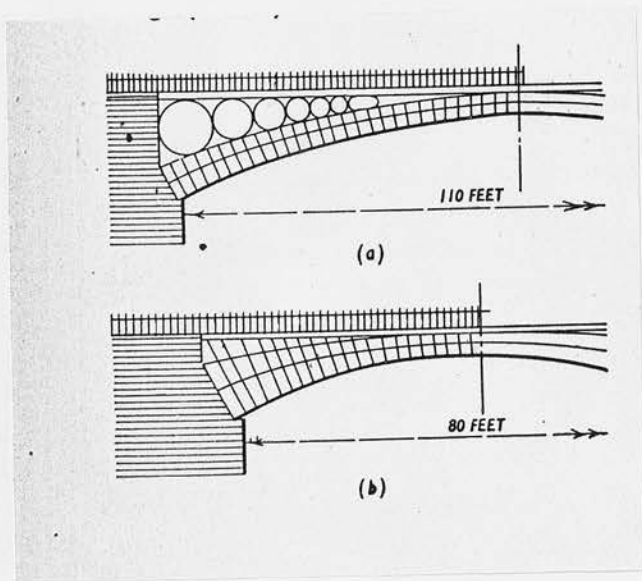


Plate 9. Bridge designs for St. Nevis by John Rennie.  
 (a) 1791. (b) 1794.

grounds of expense. The initiative to use iron seems to have been taken by Roland Burdon,<sup>36</sup> who was the M.P. for Durham. He chose the Walker Foundry at Rotherham and also employed a local engineer, Thomas Wilson. The design is very closely related to Paine's bridge and Paine felt rather aggrieved that Burdon had made such obvious use of his ideas and models.<sup>37</sup> The astute Burdon took out a patent,<sup>38</sup> partly at the insistence of the founders, for the mode of construction being used on the Sunderland Bridge. The patent clearly shows the main constructive elements in the bridge. (See Plate 10) Fig.I shows the basic element, five feet in depth and two feet wide. The three arms have a  $\frac{3}{4}$  inch groove to receive bars of malleable iron as connectors. Fig.II shows two of these elements bolted together and connected transversely by flanged hollow tubes six feet long and four inches in diameter.

Work went ahead on the Sunderland Bridge at the Walker Foundry during 1793-5 and it was erected in the latter part of 1795 in a surprisingly short time - only ten days were taken to erect the six main ribs.<sup>39</sup>

<sup>36</sup> Burdon also provided the lion's share of the capital - £22,000 out of a total of £26,000.

<sup>37</sup> Thomas Paine, Memoir etc., (Philip S. Foner), op.cit., p.1054.

<sup>38</sup> No.2066, 18th September 1795. Making, uniting, and applying cast-iron blocks in lieu of key stones, in the construction of arches. See also, The Repertory of Arts and Manufactures, Vol. V, 1796, pp. 361-4.

<sup>39</sup> Account of the Wearmouth Bridge, The Repertory of Arts and Manufactures, Vol.V, 1796, p.367.



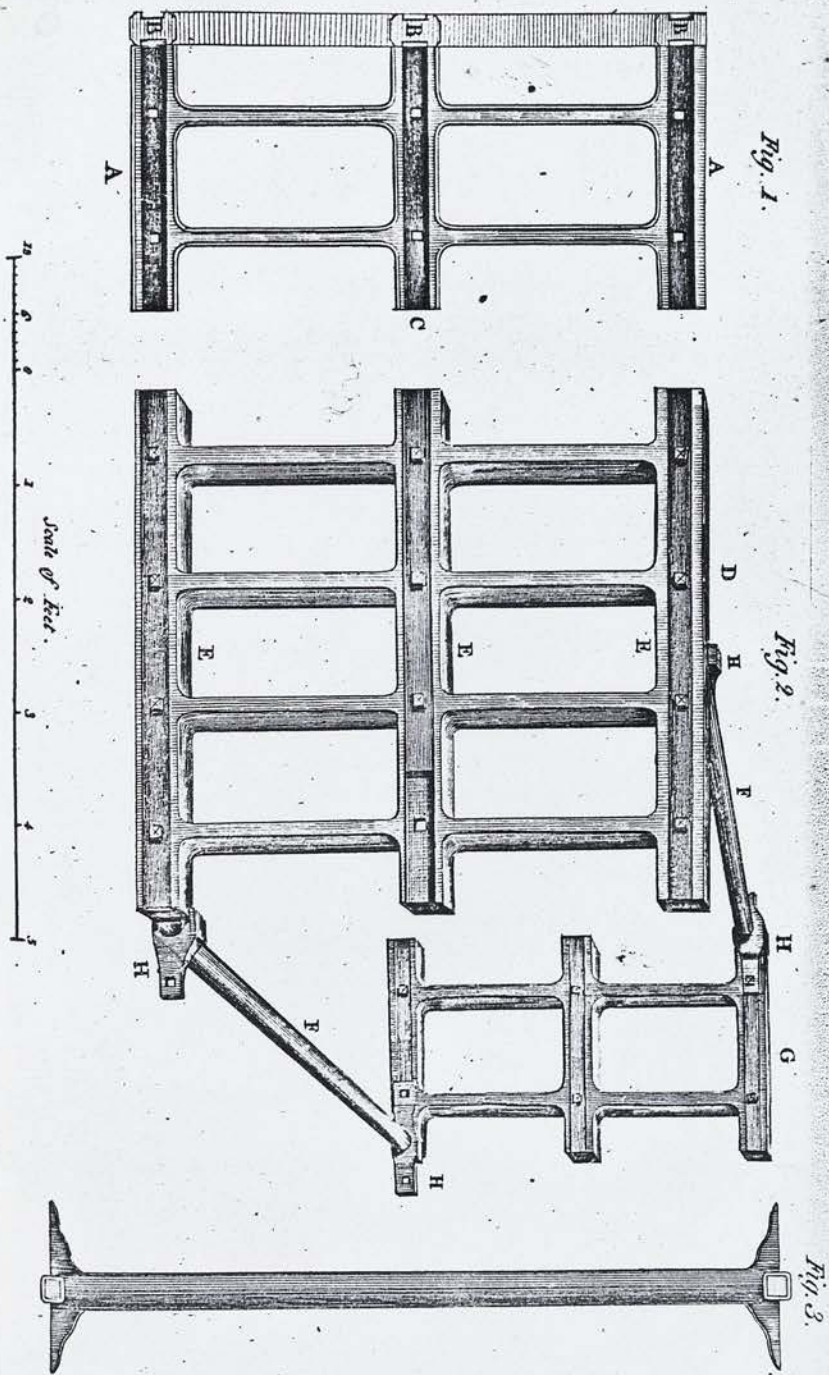


Plate 10. Drawing from Roland Burdon's Patent for iron bridge construction, 18th September, 1795 (No. 2066)

The constructed bridge could never be described as elegant, but certainly was spectacular and daring with the sweeping curve of its 236 feet span soaring 100 feet over the river. (See Plate 11). The true extent of the debt to Paine's Paddington bridge can never be determined as no drawing of the Paddington bridge survives. But the fact that Paine's model was left in the Walker Foundry and that the components of the Paddington Bridge were taken back there - some authors claiming their re-use in the Sunderland Bridge<sup>40</sup> - certainly establishes the closest possible links between the two.

By the mid 1790's bridge building in iron was firmly established. Telford built Buildwas in 1795, and in the next five years large numbers appeared throughout the country.<sup>41</sup>

However, not until 1800 was Paine's dream of the truly portable iron bridge to be realized when the Walker Foundry started to construct a bridge to be exported to Spanish Town, Jamaica. (See Plate 12). The Bridge of 82 feet span was sent to Hull and loaded aboard "the 500 ton ship 'Ellison' on November 28th"<sup>42</sup> and dispatched in December. It arrived in the following May and was erected later that year over the Rio Cobre, where it still stands to this day. The

<sup>40</sup> J. C. Jeaffreson, The Life of Robert Stephenson, F.R.S. 1864, Vol. II, Chapter II, p. 34.

This chapter, written by William Pole, mentions that Mr. Murray of the Sunderland Dock examined the bridge and "succeeded in identifying in it the particular portion of ironwork ... which differs in manufacture from the rest."

<sup>41</sup> J. G. James, Some Early Cast Iron Bridges, The Engineer, January 29th, 1965, p. 204.

<sup>42</sup> J. G. James, Letter, The Engineer, August 20th 1965, p. 30.

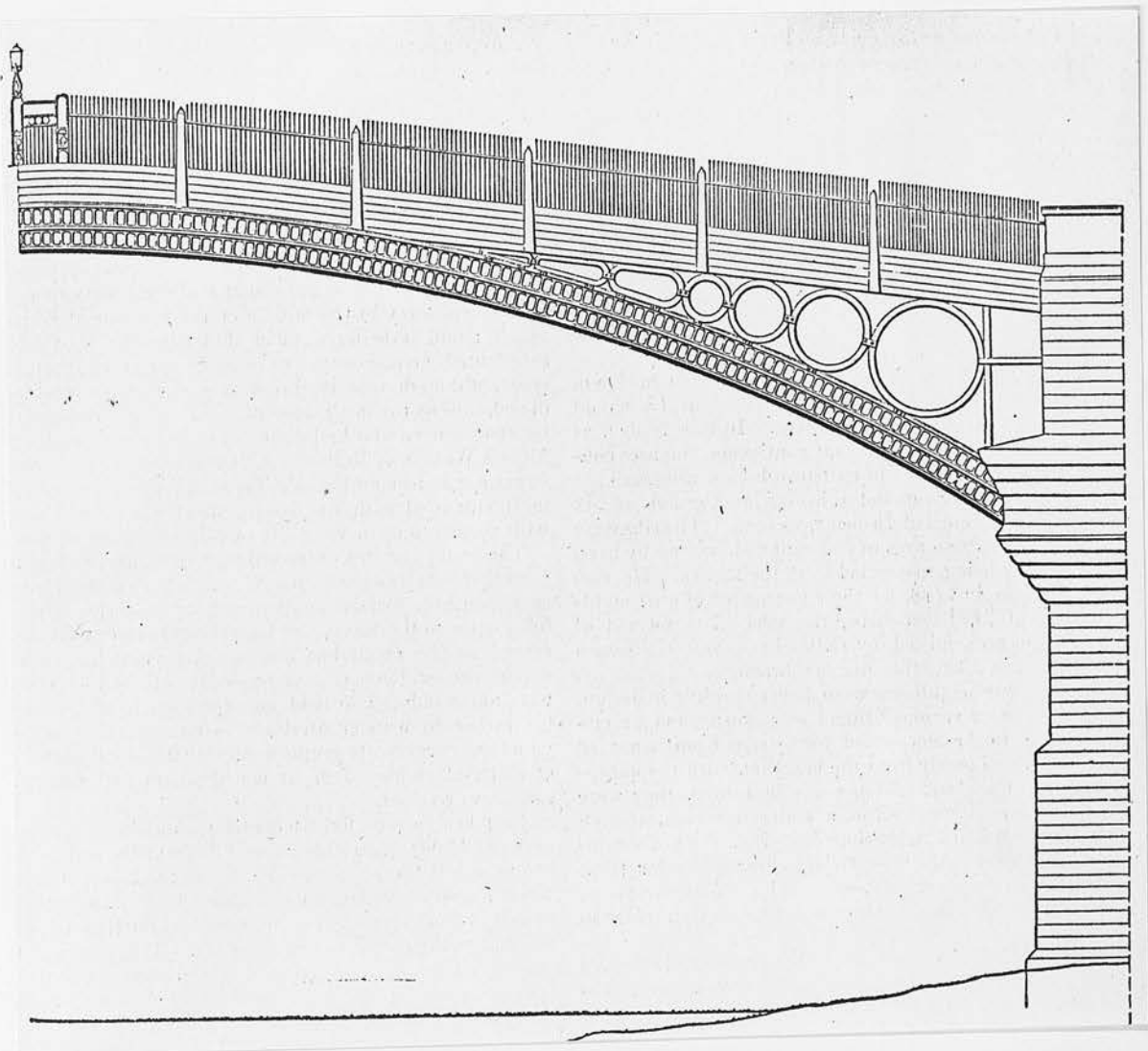


Plate 11. Bridge over the Wear at Sunderland, by Roland Burdon and Thomas Wilson, 1793-6.

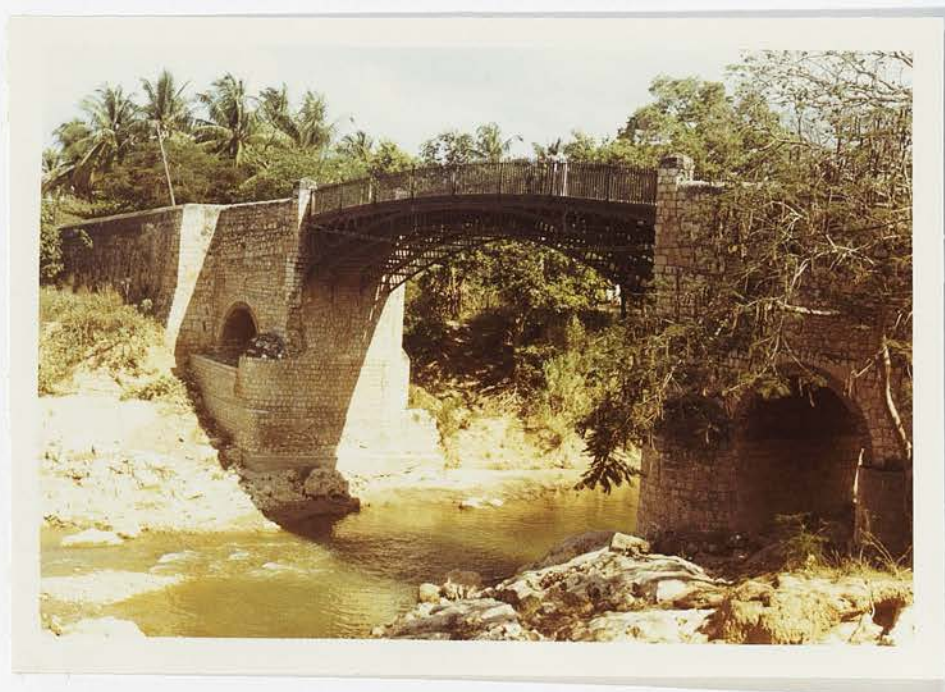


Plate 12. Bridge over the Rio Cobre, Spanish Town, Jamaica, 1801.

details exactly follow the Burdon patent and the Sunderland Bridge,<sup>43</sup> but the idea that came to its successful conclusion in the Spanish Town Bridge was certainly Thomas Paine's.

In the years between Pritchard's design of 1775 and the Spanish Town Bridge of 1801, a technical skill in casting and erecting iron structures had been developed with astonishing rapidity. In addition it had been shown how this skill could be combined with the production of a truly portable structure.

## CHAPTER II

### The Napoleonic Wars and the beginnings of iron architecture.

<sup>43</sup> J. G. James, Some Early Cast Iron Bridges, p. 204.



From 1793 to 1815, except for the brief interlude of the Peace of Amiens, Great Britain was at war with France.

Although the economic consequences of this were complex, two main factors affected the growth of the use of iron in building. Firstly, the iron industry grew rapidly as a result of the war effort, and secondly, but perhaps of greater importance, the considerable quantities of timber normally imported were seriously interrupted by the war, especially after 1806 when France successfully blockaded the European coast, in particular, the Baltic ports.

It was in this context that attempts were made to produce building systems where iron was the principal structural and structural

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<sup>1</sup> T. S. Ashton, *Iron and Steel in the Industrial Revolution*, 3rd edition, Manchester, 1947, pp. 97-8. The total output of pig iron in Great Britain rose from 125,400 tons in 1795 to 250,400 in 1806.

<sup>2</sup> *Recherches*, 10th June 1809. 'A new Arch, or Method of Making and Constructing Bridges, Warehouses and other Buildings, without the Use of Wood as a necessary Component Part thereof, and with other Advantages and Improvements appertaining thereto.'

From 1793 to 1815, except for the brief interlude of the Peace of Amiens, Great Britain was at war with France.

Although the economic consequences of this were complex, two main factors affected the growth of the use of iron in building. Firstly, the iron industry grew rapidly as a result of the war effort,<sup>1</sup> and secondly, but perhaps of greater importance, the considerable quantities of timber normally imported were seriously interrupted by the war, especially after 1806 when France successfully blockaded the European, and, in particular, the Baltic ports.

It was in this context that attempts were made to produce buildings where iron was the principal constructional and structural material. The first attempt was a patent taken out by Samuel Wyatt in 1800.<sup>2</sup> It was a constructional system deliberately seeking to use iron as an alternative to wood. To some extent this design is an extension of the iron-framed mill building evolved in the 1790's, but developed the idea to produce a four-fold symmetrical continuous vault of iron plates, (See Plates 13 & 14), instead of a series of barrel vaults in brick.

<sup>1</sup> T. S. Ashton, Iron and Steel in the Industrial Revolution, 3rd edition, Manchester, 1963, pp. 97-8. The total output of pig iron in Great Britain rose from 125,400 tons in 1796 to 250,400 in 1806.

<sup>2</sup> No. 2410, 10th June 1800. A new Arch, or Method of Making and Constructing Bridges, Warehouses and other Buildings, without the Use of Wood as a necessary Constituent Part thereof, and with other Advantages and Improvements appertaining thereto.

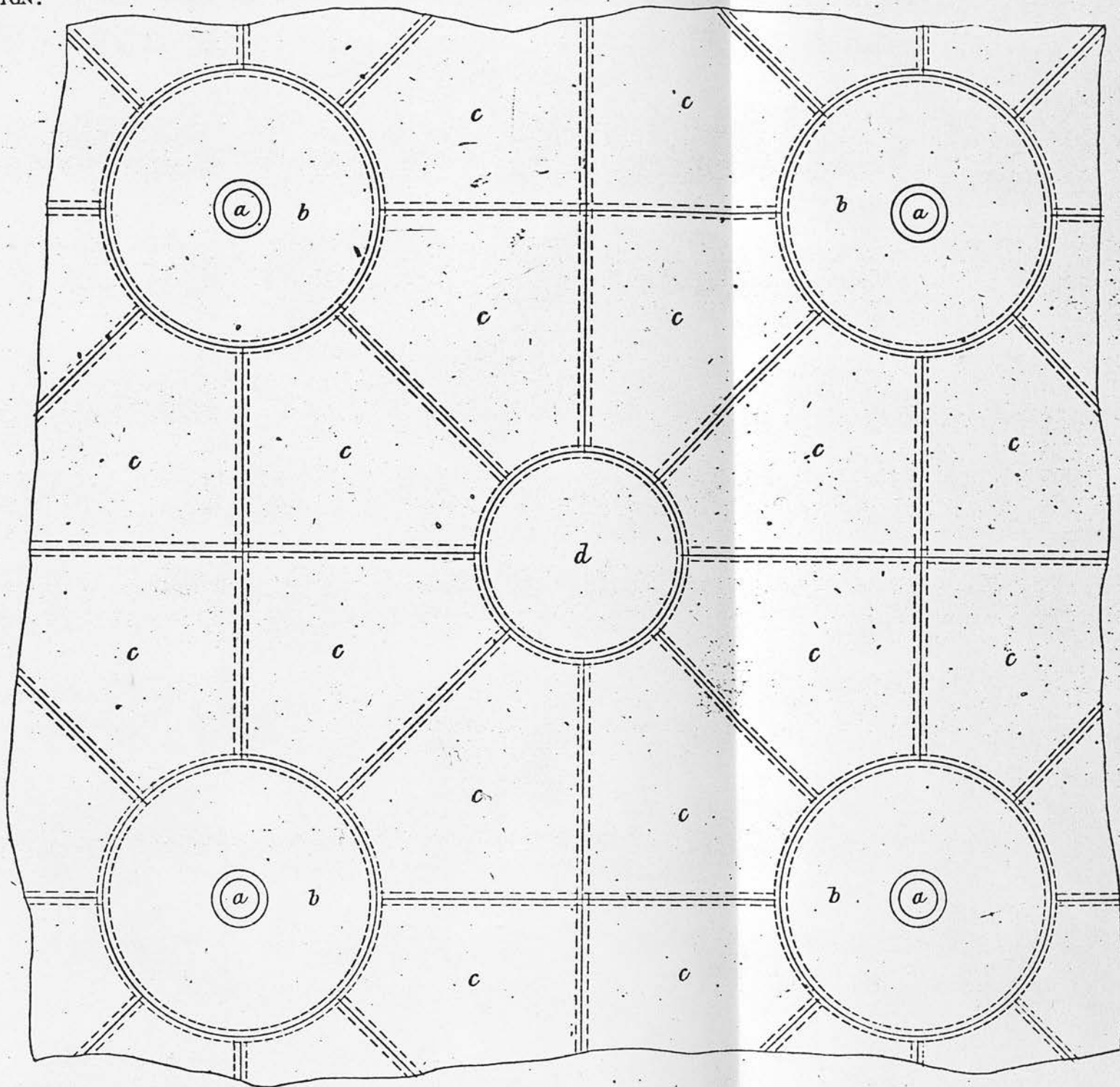
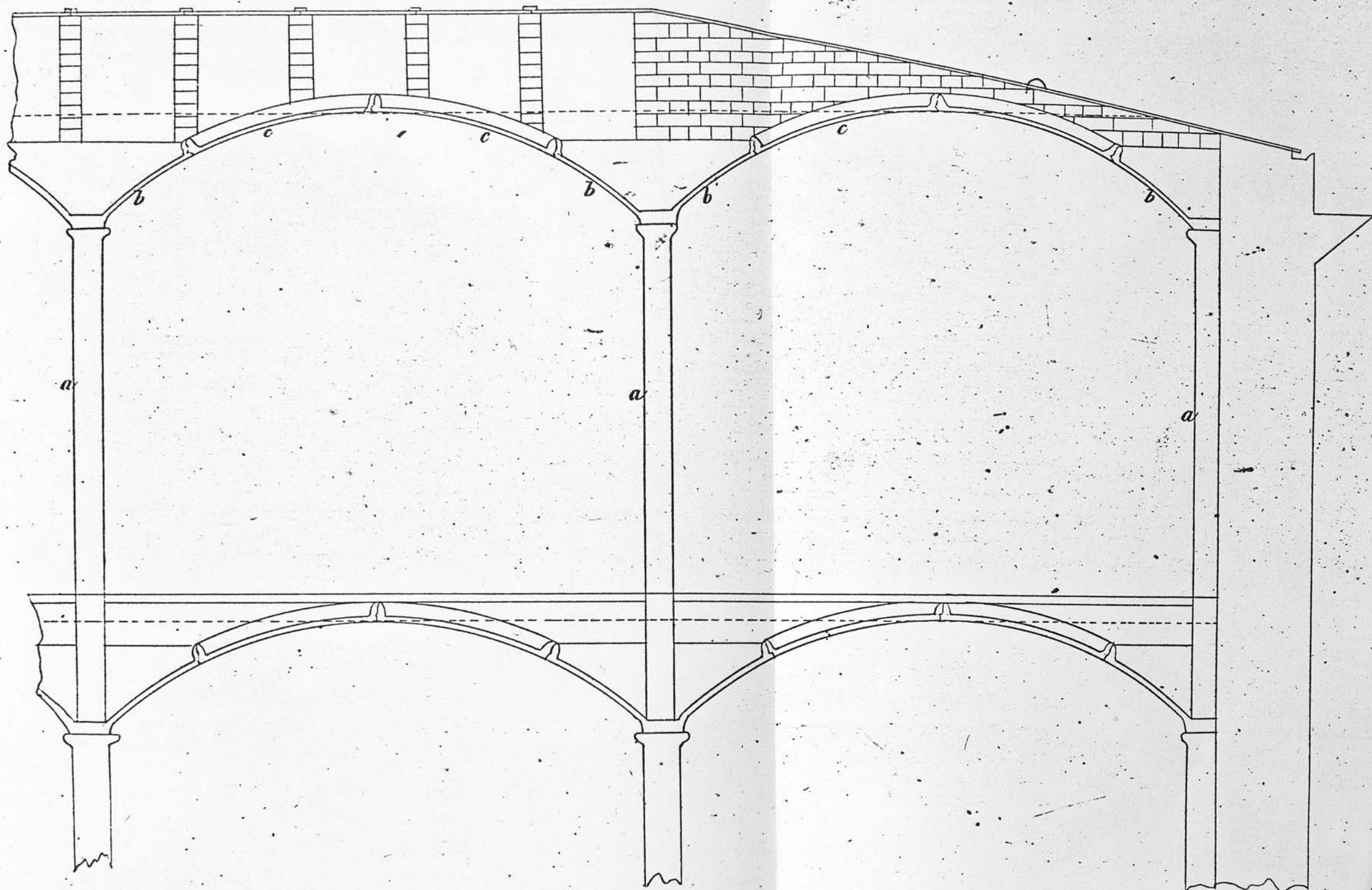


Plate 13. Ceiling plan from Samuel Wyatt's Patent No. 2410,  
10th June, 1800.



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Wyatt was familiar with warehouse construction and its associated problems<sup>3</sup> but this patent represents a step forward to the use of iron to achieve an altogether more sophisticated form. The ceiling components were all of similar size and had no greater dimension than 4 feet. Their edges were flanged and grooved and the joints run with lead or cement. On top of the vaulting rested a system of sleeper walls, and these in turn supported a timber floor.

We have no evidence that Wyatt ever used his patent in any building.<sup>4</sup> The remaining seven years of his life were largely spent as Clerk of the Works at Chelsea Hospital, where he died at the age of seventy in 1807.

Although impossible to prove, it seems very likely that his patent, or something based on it, was used by James Wyatt in his castellated Palace for King George III at Kew in 1802. Wyatt Papworth describes the building as "all of cast iron, after his (James Wyatt's) invention, patented 1808, except the floorboards."<sup>5</sup> There are two points to be noticed in this statement: there is no record of a patent granted to James Wyatt in 1808, or at any other date, and Samuel Wyatt's patent (See Plate 14) could certainly be

<sup>3</sup> A. W. Skempton, Samuel Wyatt and the Albion Mills, Architectural History, Vol. 14, 1971, pp. 53-73.

<sup>4</sup> He did however produce designs for the rebuilding of the Albion Mill in 1802 using the patent. This project was not built. See A. W. Skempton op. cit., p. 71, drawings 22 and 23.

<sup>5</sup> A. P. S. D. Art. James Wyatt.



described as "all of cast iron ... except the floorboards."

Further evidence is given in a letter from George Dance to Sir John Soane, dated July 30th 1802, which discusses Dance's project of iron trusses and mentions Wyatt's floors at Kew.<sup>6</sup> When we look at the plan, (See Plate 15) we notice that all the rooms are small, indeed it was described by a contemporary topographer as having "rooms no more than a series of large closets, boudoirs and oratories."<sup>7</sup> Wyatt's patent relied on short spans and could certainly have been adapted to this plan.

There is, however, another patent of the right date (1808) which was taken out by Ralph Dodd, the engineer.<sup>8</sup> His patent<sup>9</sup> does more accurately fit Papworth's description, as walls, floors, and roof were all to be of iron. However a date alone is really rather slim evidence that this patent was used. Whether or not it was used at Kew, it represents a considerable attempt at formulating a vocabulary of iron architecture.

<sup>6</sup> Arthur T. Bolton, The Portrait of Sir John Soane, R.A. (1753-1837) set forth in Letters from his Friends (1775-1837), 1927, p. 56 and p. 94.

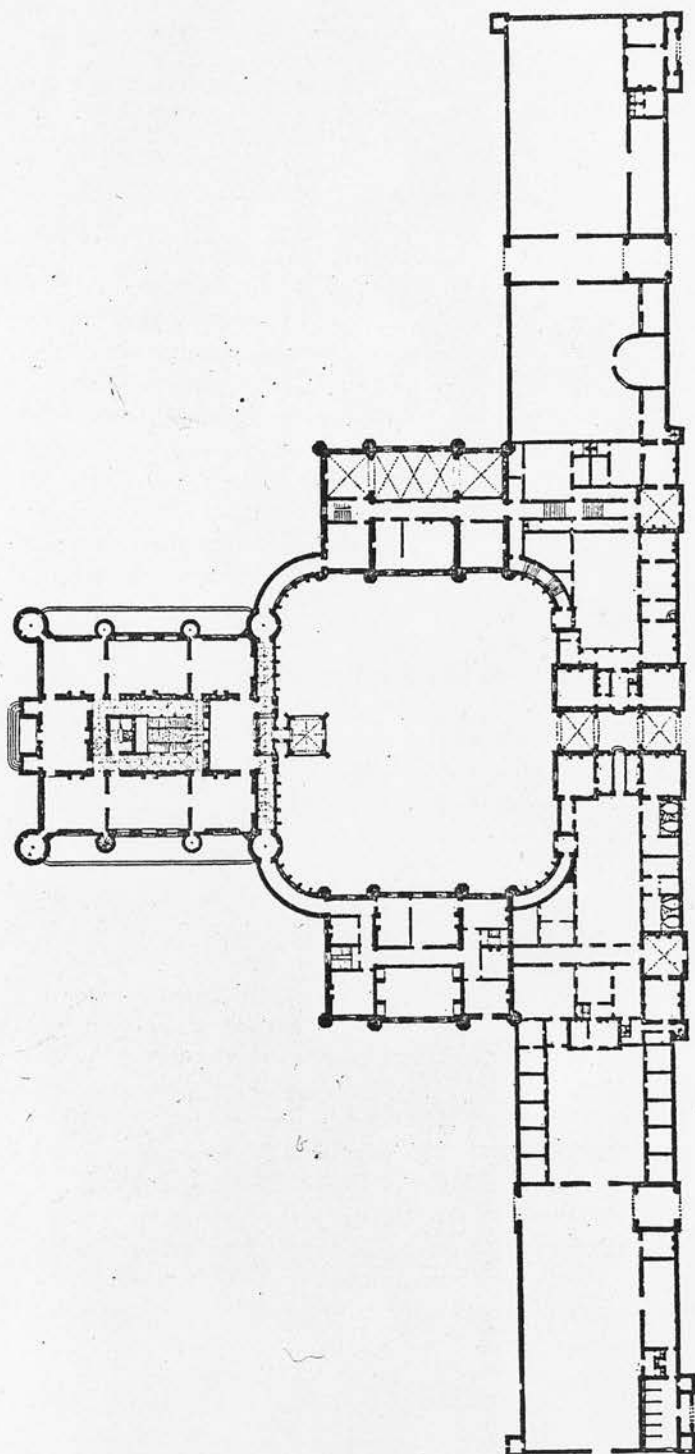
<sup>7</sup> Richard Phillips, A Mornings Walk from London to Kew, 1816, pp. 380-1.

<sup>8</sup> A project by Dodd for a bridge over the Thames with a centre span in iron of 300 feet can be seen in J. Gloag and D. Bridgewater, A History of Cast Iron in Architecture, 1948, p. 102. Dodd is also referred to in John Summerson, Georgian London, 1948, pp. 224-5 and pp. 245-6. In 1799 he submitted a design for fire-proof warehouses with iron collonades at ground floor level in connection with improvements to the Port of London. See Turpin Bannister, The First Iron-framed Buildings, Architectural Review, April 1950, p. 244.

<sup>9</sup> No. 3141, 3rd June 1808. Bridge-Floorings or platforms, and fireproof floorings and roofing, for houses, warehouses and mills.

KEW PALACE

*General Plan of his Majesty's new Lodge. Richmond Gardens.*



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Plate 15. Plan of the New Palace at Kew by James Wyatt, 1802-11.

It also took the idea of fireproofing one step further. (See Plate 16). Dodd envisaged his components, which were principally iron tubes of various sections, being coated or filled with artificial stone. Although he does not refer to the reason for this, it is now recognised as one of the principal ways of protecting metal components from fire.

It must be admitted that there exists a rather unexplained gap between the drawings of simple components and the facades which he shows (Plate 16, fig. 13) when the "various parts" are "combined in the formation of houses, warehouses, or mills."<sup>10</sup> However the ideas that the patent embodies must be acknowledged as a remarkable advance on any previous concept of iron construction in fireproof buildings.

Work dragged on at Kew until 1811, when the building was nearly covered in, by which time it had cost the excessive sum of £500,000. It remained in this unfinished condition until 1827-8 when it was demolished by order of George IV. Nothing substantial remains of the building so that the perplexing problem of its construction will remain a mystery until fresh documentary evidence is unearthed.

Another royal building, built in 1807, presents a rather similar puzzle in the extent to which iron was used. This was Thomas Hopper's gothic conservatory at Carlton House. Dutton describes it as "principally in cast iron"<sup>11</sup> and Hitchcock is even more extravagant in calling it "Hopper's ornately Gothic Conservatory of iron and glass"<sup>12</sup>

<sup>10</sup> Repertory of Arts and Manufactures, Vol. XIV, 1809, p. 147.

<sup>11</sup> Ralph Dutton, The English Interior, 1500-1900, 1948, pp. 147-8 and Plate 123.

<sup>12</sup> H. R. Hitchcock, Architecture 19th and 20th centuries, 2nd edition, 1963, p. 120.

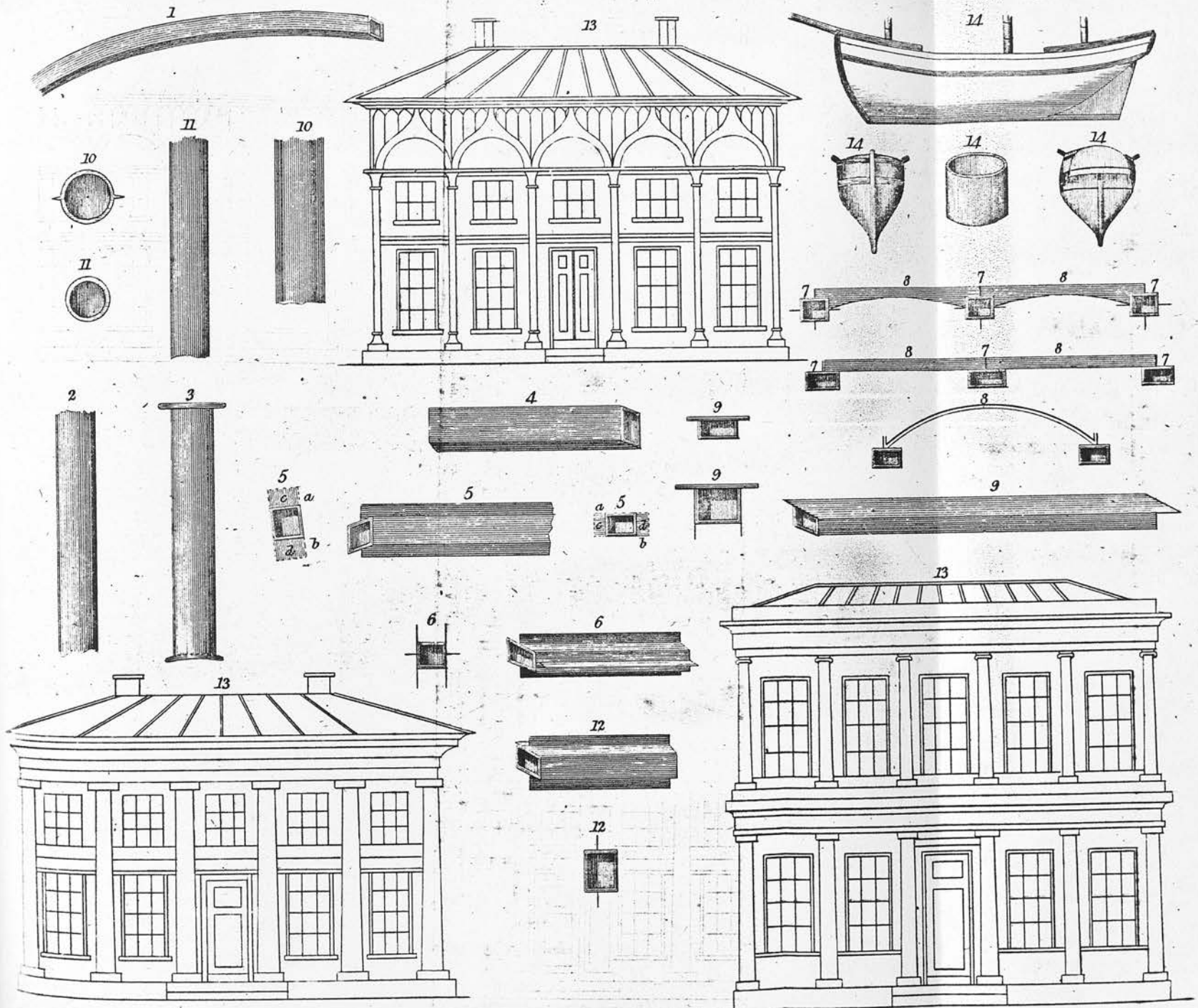


Plate 16. Drawing from Ralph Dodd's Patent No. 3141, 3rd June 1808.

Neither of these claims can be substantiated; indeed Pyne's illustrations<sup>13</sup> show such diverse decoration that iron castings are most improbable. Furthermore Pyne, who had the benefit of actually viewing the building, described it as having "rows of clustered carved pillars"<sup>14</sup>.

As no drawings have yet come to light, one can only guess what materials were used. Some hidden iron framing might have been used, but most of the detail which shows in Pyne's illustrations would probably have been in timber and plaster.

The next major step in the use of iron concerns theatre design. The burning of Covent Garden in 1808 and of Drury Lane the following year provoked many pleas for fireproof construction. However neither Smirke at Covent Garden, nor B.D. Wyatt at Drury Lane, used iron in any major way. But iron was used extensively in 1811 in the construction of the Theatre Royal in Plymouth.

John Foulston, a local architect, had been successful in the competition the previous year for a group of civic buildings, which included a most remarkable iron framed theatre. How Foulston arrived at his very fully developed solution is something of a mystery. Jenkins<sup>15</sup> suggests that Foulston may have got his ideas from

<sup>13</sup> W.H. Pyne, The History of the Royal Residences of Windsor Castle etc. 1819.

<sup>14</sup> Ibid., Vol. III, p. 84.

<sup>15</sup> Frank Jenkins, John Foulston and his public Buildings in Plymouth, Stonehouse and Devonport, Journal of the Society of Architectural Historians, May 1968, p. 128 and note 24.



B.D. Wyatt's pamphlet of 1811,<sup>16</sup> in which a system of iron framing rather similar to the Plymouth solution is described. This pamphlet was published after the competition had been won by Foulston, and as the competition drawings are lost, we do not know if Foulston made changes in the theatre design before construction began.

Fortunately he left us a splendid record of the theatre in an ambitious book on his buildings, published in 1838.<sup>17</sup> (See Plates 17-22). His motive for using iron was quite simply an attempt at fireproof construction. He rather extravagantly described it as "the only fireproof theatre in the country"<sup>18</sup>. It could never be described as fireproof as the iron frame was not protected.

The plan of the auditorium, in the form of a three-quarter circle, necessitated a very complicated system of framing, which was extremely elegantly constructed. The structure consisted of a series of stepped, pierced, principals (B on Plates 18 and 19) spanning 10 feet from a framed iron partition (Plate 20, Fig. 2) to a curved beam (a on Plate 18) at the front of the boxes. This beam in turn rested on fluted iron columns at 10 feet centres around the curve of the auditorium.

The technique of assembly was either by bolting - as with the joining of the principals over the boxes and corridor (E on Plate 19)

<sup>16</sup> B.D. Wyatt, Observations on the Principles of a Design for a Theatre, 1811.

<sup>17</sup> John Foulston, The Public Buildings erected in the West of England, 1838.

<sup>18</sup> Ibid., p. 18.

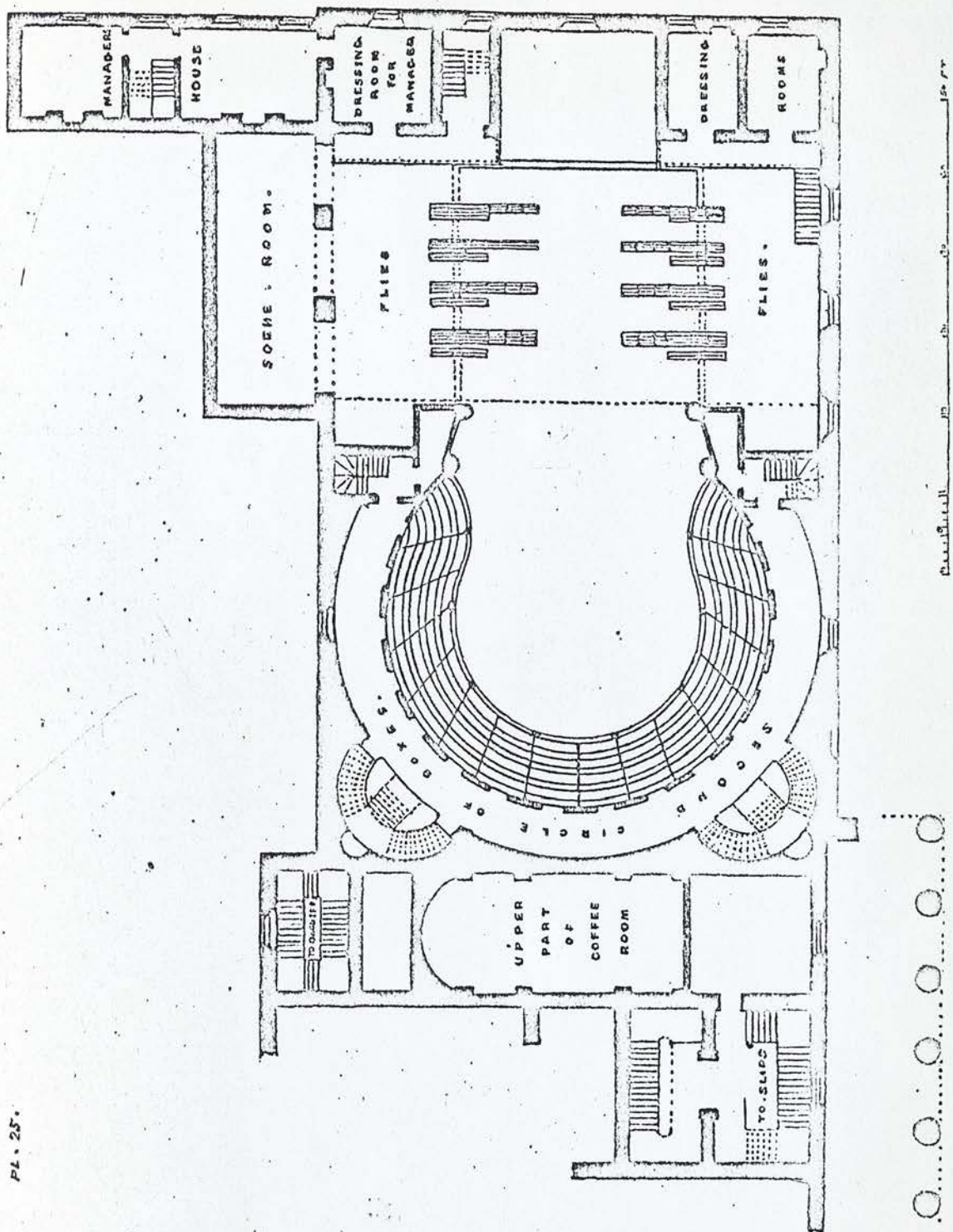
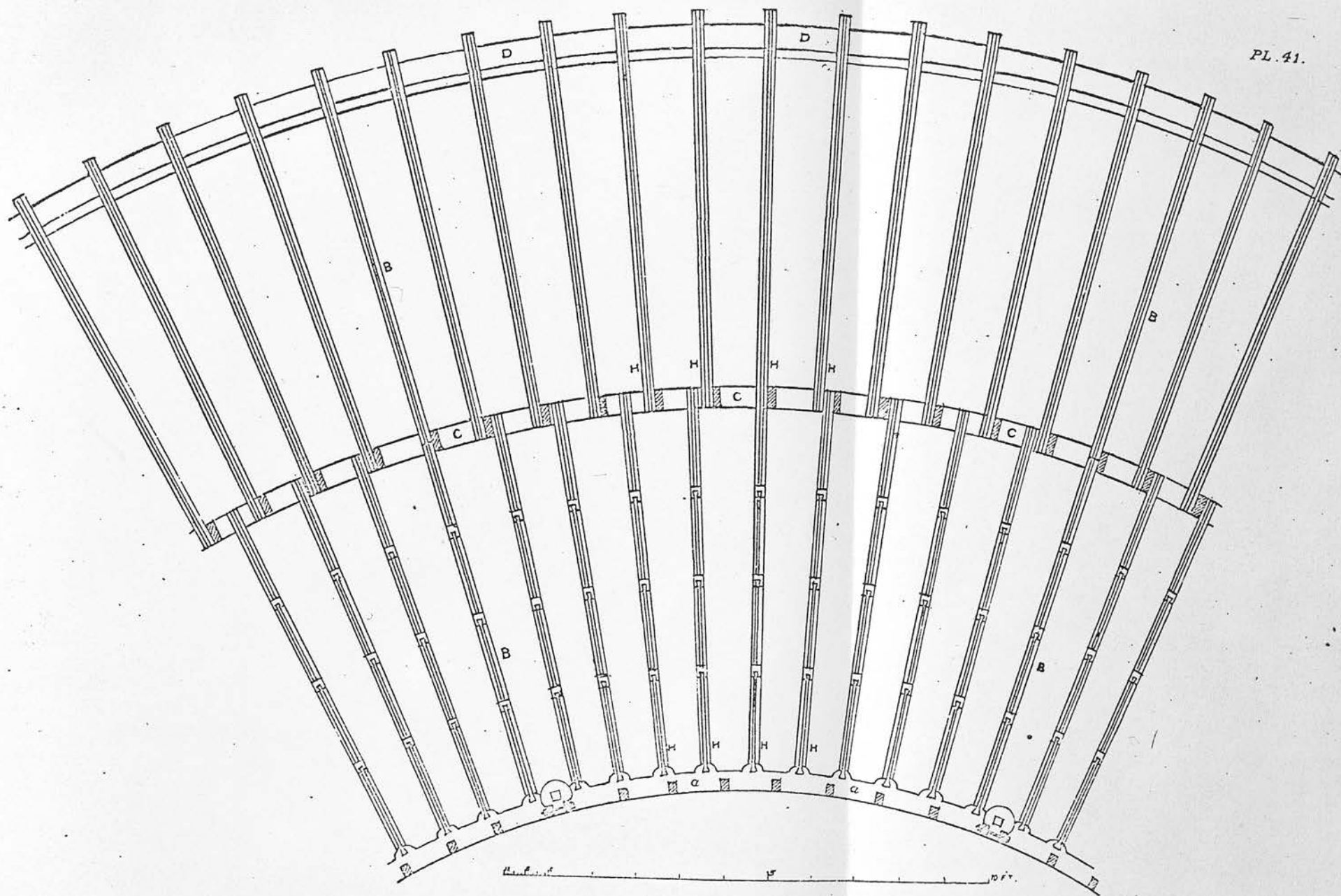


Plate 17. Theatre Royal, Plymouth by John Foulston, 1811-13.  
First Floor Plan.



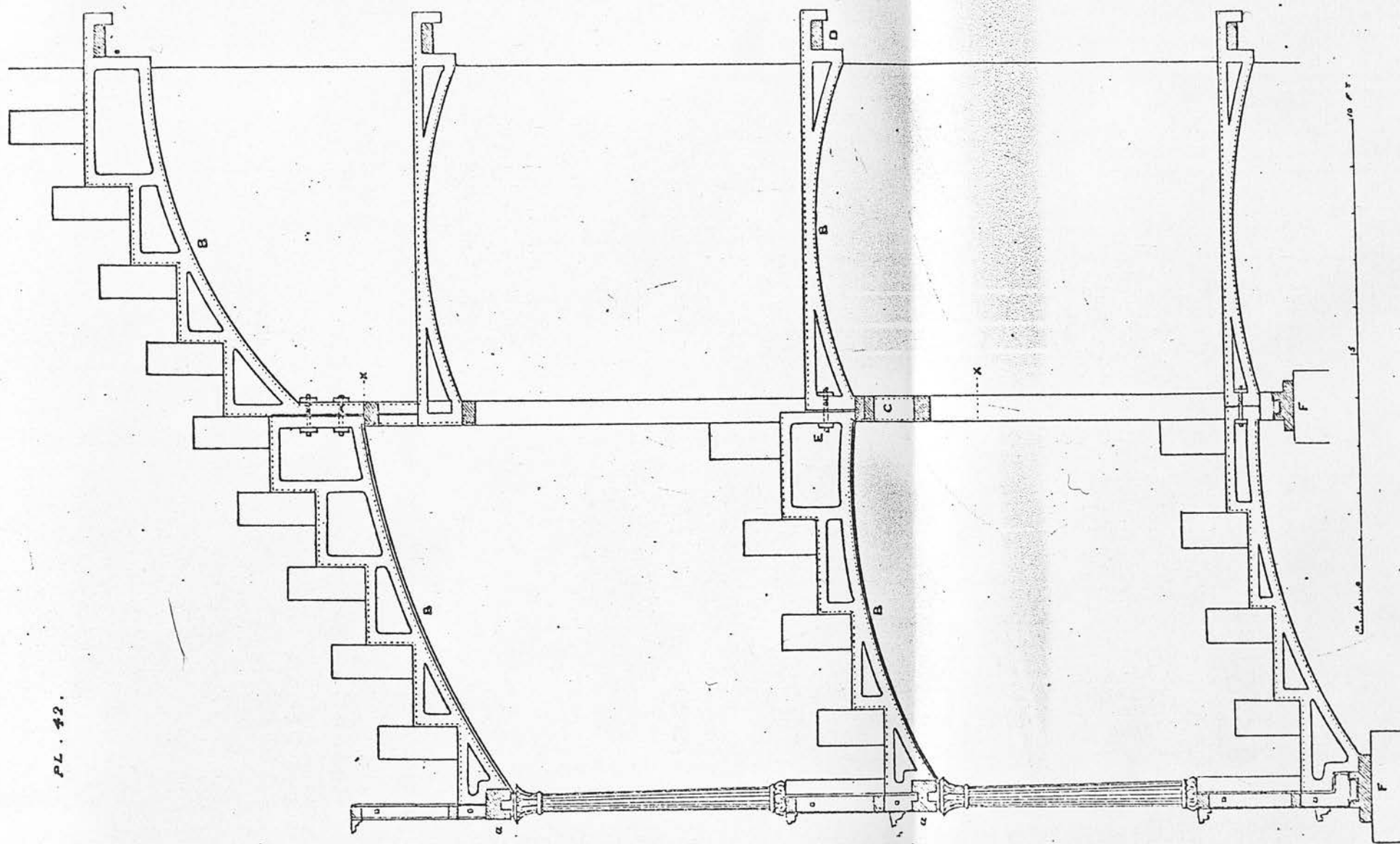
ON STONE BY T. J. R.

J. F. ARCHT.

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Plate 18. Theatre Royal, Plymouth. Plan of Iron Work to Boxes and Corridors.





PL. 42.

Plate 19. Theatre Royal, Plymouth. Cross section of Iron Work to Boxes and Corridors.

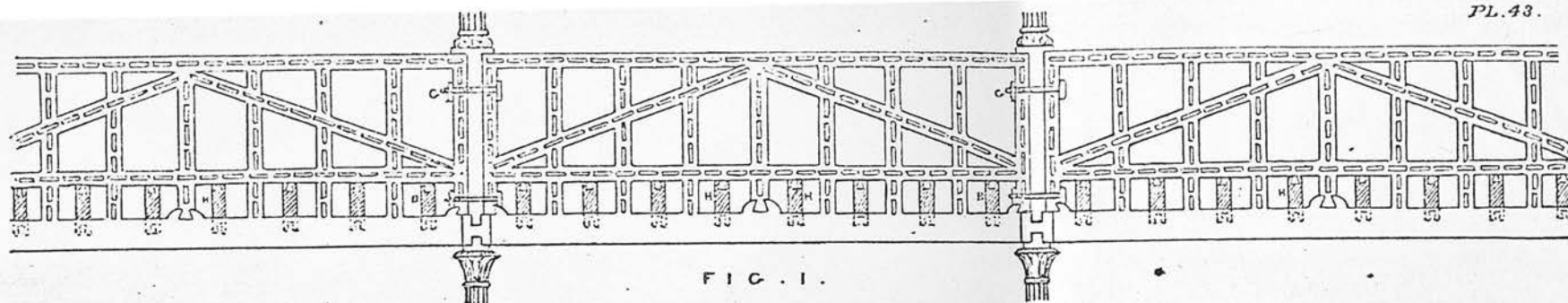


FIG. I.  
FRONT OF BOXES.

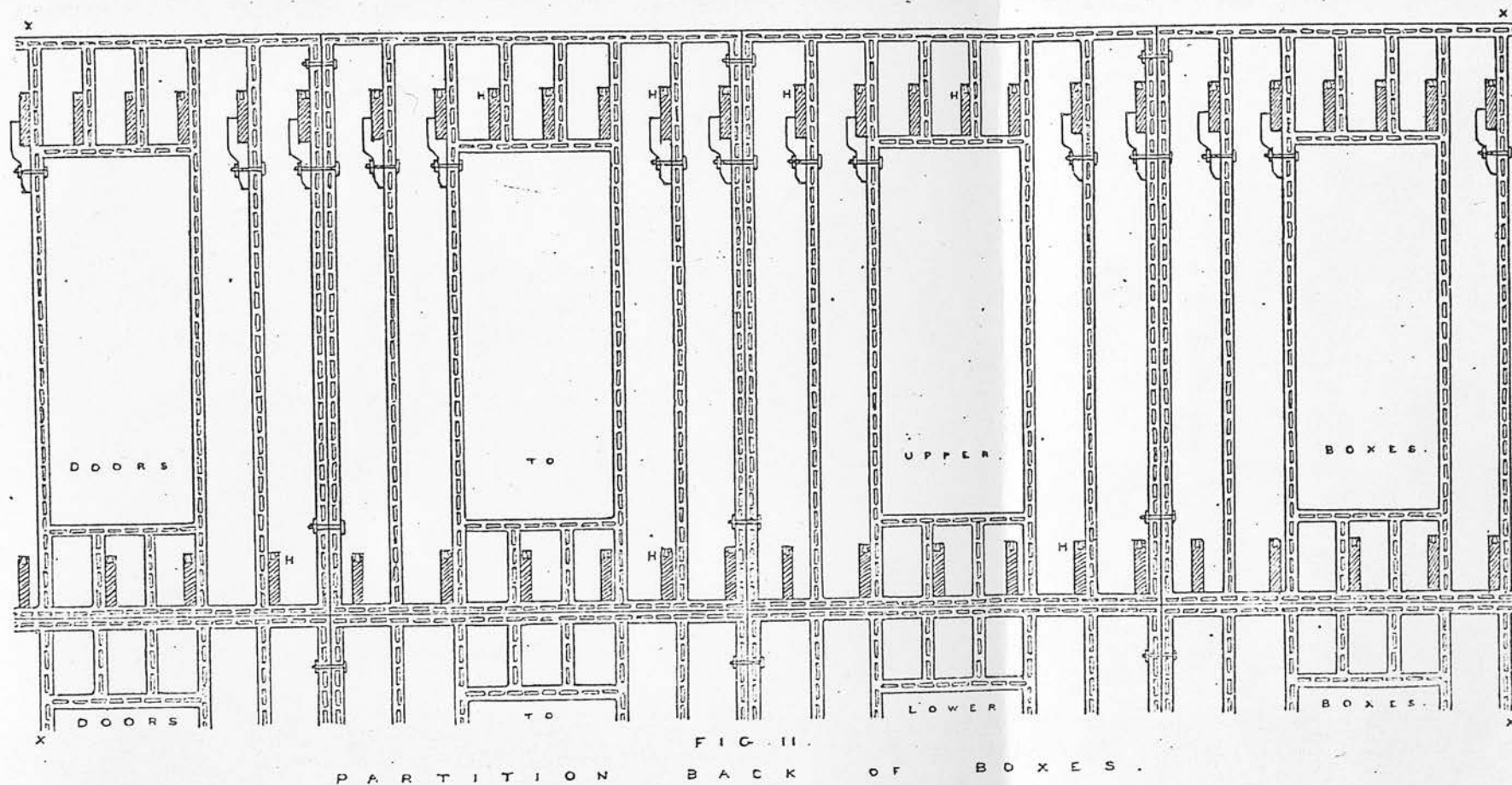


FIG. II.  
PARTITION BACK OF BOXES.

120 F.T.

ON STONE BY T. J. R.

J. F. ARCHT.

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Plate 20. Theatre Royal, Plymouth. Fig. 1. Iron Work to front of Boxes. Fig. 2. Partition between Boxes and Corridors.



or by morticing, where the principals join the transverse beam at the front of the boxes (Fig. 1, Plate 21). The same morticing device was used to allow timber flooring and lath ceilings to be attached to the iron principals. The iron principals were cast with a groove (T on Fig. VII, Plate 21) and timber was then driven in to give a fixing for the floor or ceiling. A similar technique was used for the partition at the back of the boxes (Plate 20, Fig. 2) where the slots were again plugged with timber as fixings (S on Fig. IV, Plate 21).

The roof, where iron was again used, presents a less well conceived design (Plate 22). The main rib (A) was formed of two pieces of rolled iron  $3'' \times \frac{3}{16}''$  thick (Fig. 11), connected together by a curious device of three pieces of iron (P), which passes through holes in the rib, "Iron straps are passed through them, and around the three horizontal pieces and clenched perfectly tight by which the two ribs, and the three horizontal pieces are firmly united, and each acting on its edge, in opposite directions, produces when connected with the tie pieces D, and suspended pieces B, a rib of uncommon strength".<sup>19</sup> The ribs were placed at 7 feet centres with supports (C) for the rafters. On the rafters were laid iron laths ( $1\frac{3}{4}'' \times \frac{1}{8}''$ ) and the slates were fixed directly to these laths by horseshoe nails which were clenched around the laths.

Although it was some achievement to avoid the use of timber so completely and to produce such a lightweight roof,<sup>20</sup> the design can only be

<sup>19</sup> Ibid., p. 34.

<sup>20</sup> Ibid., p. 35. Foulston calculated that it weighed little more than half a timber roof of equivalent span.

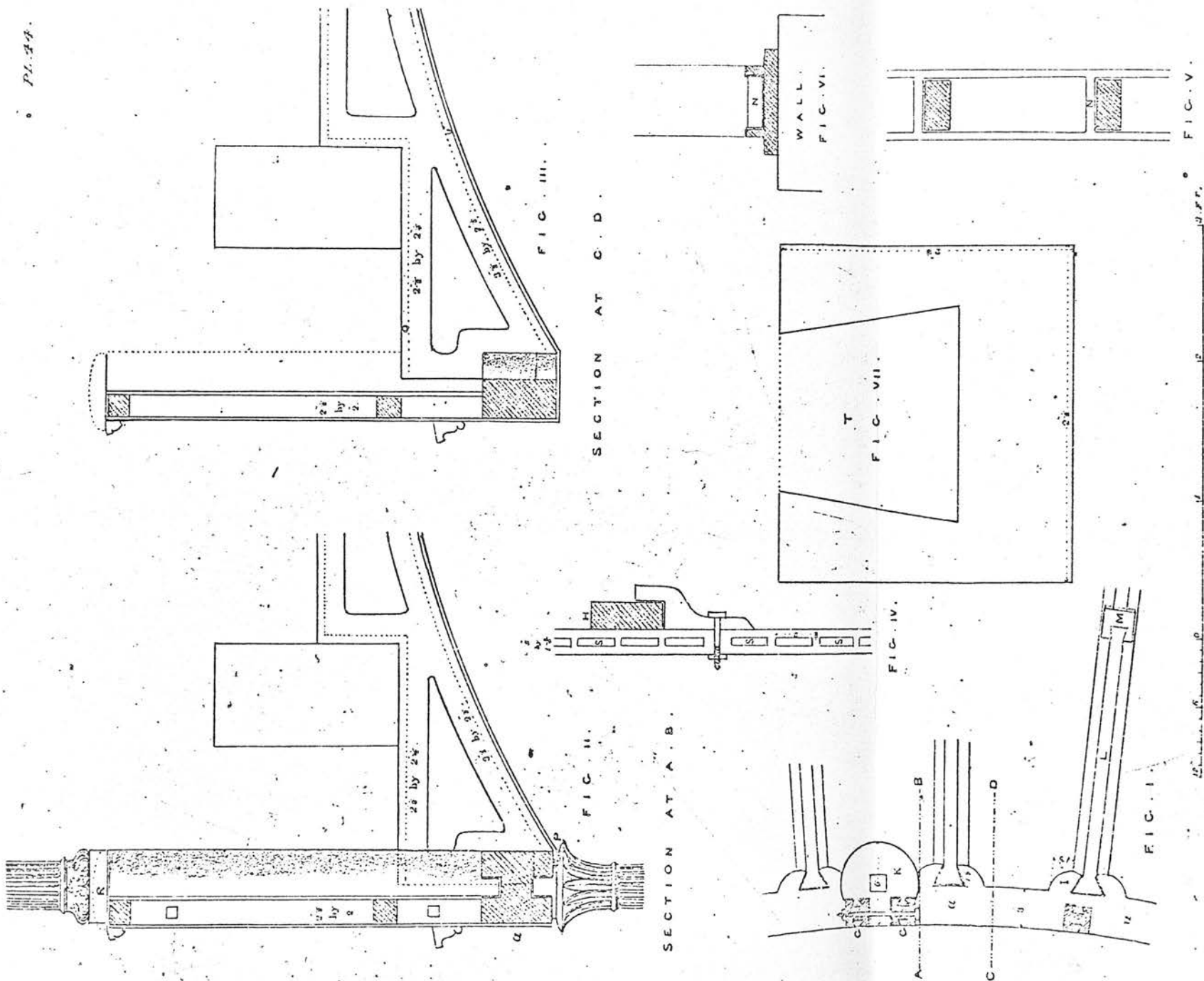


Plate 21. Theatre Royal, Plymouth. Details of Iron Work to Boxes.

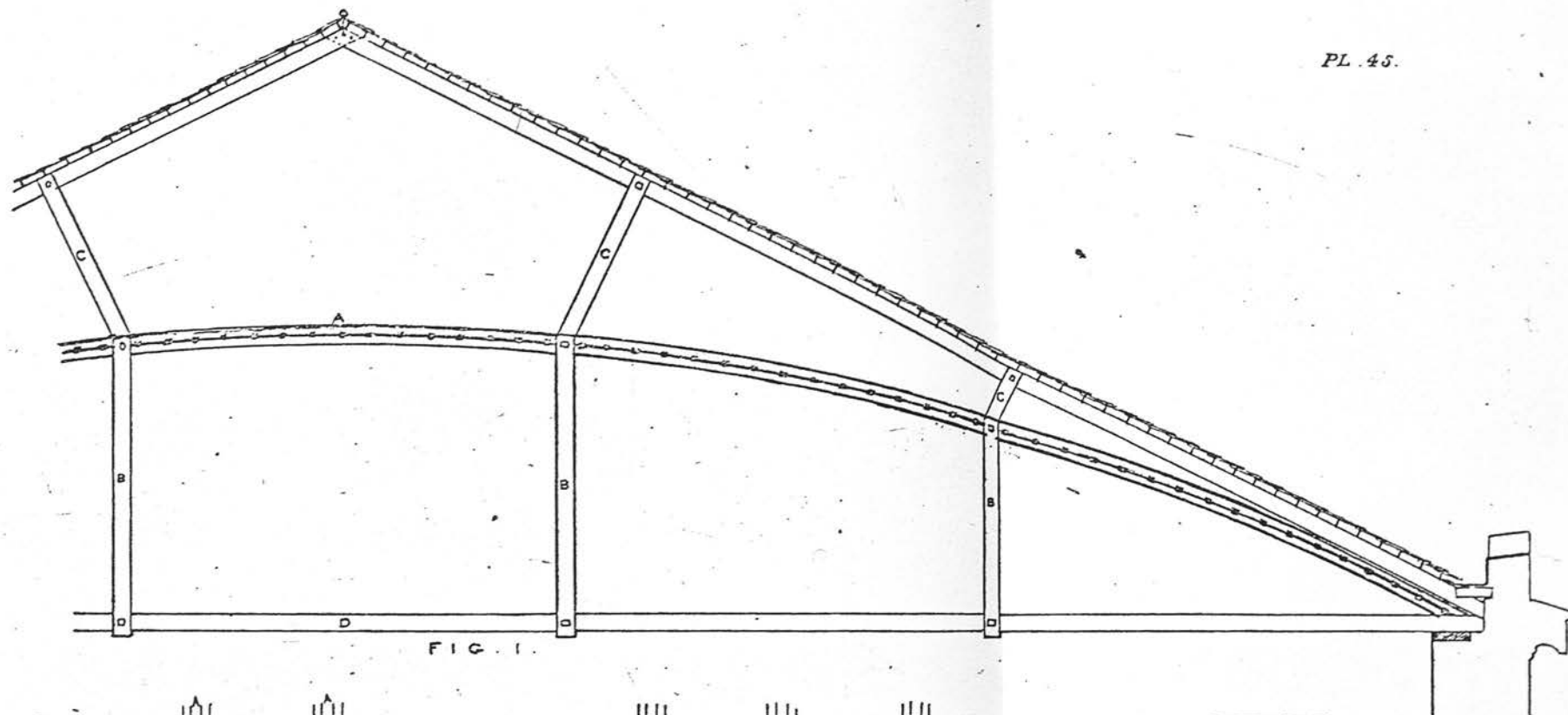


FIG. I.

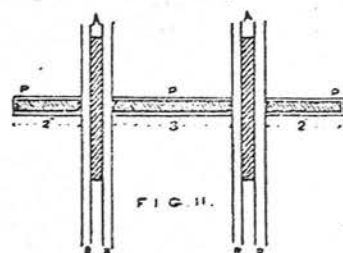


FIG. II.

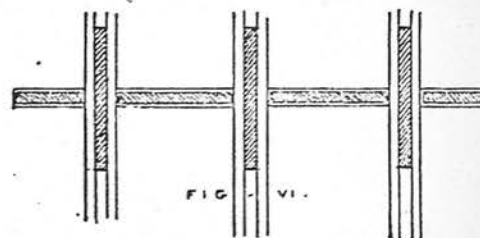


FIG. VI.

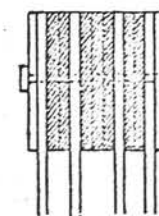


FIG. IV.

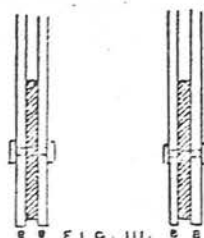


FIG. III.

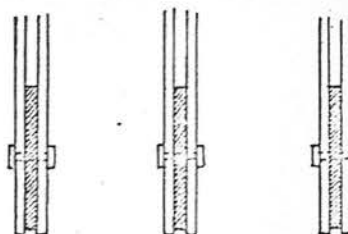


FIG. VII.

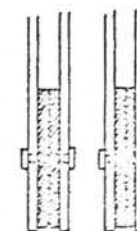


FIG. V.

ARCHT. ON STONE BY T. J. R.

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described as very unsophisticated. Foulston himself comments that the ribs and rafters were "laced and braced together in a variety of ways, but not in so scientific a manner as could have been wished, a great part having been done while the author was away in London".<sup>21</sup> In spite of its constructional deficiencies, the building lasted until 1939, when it was partially demolished. It was finally destroyed in an air raid in 1941.

The Theatre Royal, stands out as a quite remarkable achievement in pioneer iron construction: not only was it remarkable for its date, but it was achieved in a provincial city and far away from a centre of the iron industry.

The next achievement in the search for an iron architecture was the outcome of the joint endeavours of an iron founder and an architect. On April 13th 1812, John Cragg, the wealthy owner of the Mersey Iron Foundry, Liverpool, met Thomas Rickman. At this time Rickman was still employed as a clerk in the office of a Liverpool insurance broker, but he had spent much of his spare time, over several years, studying and drawing English Gothic buildings. He was at this time writing his celebrated article for Smith's 'Panorama of Art and Science'<sup>22</sup> which was reprinted later as 'An attempt to Discriminate the styles of English Architecture.'<sup>23</sup>

<sup>21</sup> Ibid., p. 34.

<sup>22</sup> James Smith, The Panorama of Science and Art, Liverpool, 1812-5, Art. Architecture, pp. 125-81.

<sup>23</sup> Thomas Rickman, An attempt to Discriminate the styles of English Architecture from the Conquest to the Reformation, Liverpool, 1817.

Cragg was an experienced ironfounder and a keen churchman. He had already experimented with the application of iron to buildings,<sup>24</sup> but it was not until he met and worked with Rickman that he developed a system of applying cast iron to Gothic church building. Cragg's wealth and his "penchant for church building"<sup>25</sup> led him to plan a proprietary chapel for his own parish, St. Michael's Hamlet, which was to be built at his own expense. When he met Rickman he was already at work on this and a series of houses in the same place.<sup>26</sup> During 1812 Rickman devoted almost all his evenings to helping Cragg on the designs for this church. Subsequently, at Cragg's request, he prepared a set of designs for a much larger church.<sup>27</sup> Rickman did not realise the significance of this request. He recorded in his diary:<sup>28</sup> "Hearing of a Meeting for the consideration of the Erection of a Church at Everton I went to it and was much surprised to find J. Cragg there and that he produced my drawings, but the thing was strongly taken up and I hope to see the work now erected in a good plan".

<sup>24</sup> Cragg's patent of 21st November, 1809, (No. 3277) describes a system of iron roofing with slate covering.

<sup>25</sup> J.A. Picton, Memorials of Liverpool, 2nd edition, 1875, Vol. II, p. 74.

<sup>26</sup> N. Pevsner, The Buildings of England, South Lancashire, 1969, p. 248.

<sup>27</sup> E.D. Colley, The Life and Works of Thomas Rickman F.S.A., M.A. Thesis, University of Manchester, 1962, p. 33.

<sup>28</sup> December 29th 1812. Quoted in E.D. Colley op.cit., p. 34.



Nevertheless Cragg and Rickman continued to work together on the design and on April 19th, 1813, the foundation stone was laid.

St. George's Everton is a remarkable building, not only as an early Gothic Revival Church, but also because of the extensive internal use of iron. Iron had been used for gallery columns on several occasions<sup>29</sup> and was beginning to be used for window tracery,<sup>30</sup> but in St. George's the entire internal structural framework is of iron. (See Plate 23).

The plan is a simple symmetrical arrangement of nave and aisles, with a tower at the West end. (See Plate 24). The slender cast iron nave columns support the galleries, which have cast iron fronts, and soar upwards to support in turn the nave and aisle ceilings.

The general effect is elegant and delicate, an effect considerably heightened by the recent repainting. Picton, although conceding it as "an immeasurable advance upon anything in the Gothic style previously attempted", as "an original composition", he found it "stiff and feeble, the common fault of all early attempts to resuscitate an extinct style".<sup>31</sup> This judgement was made after the peak of the Gothic Revival, when plan arrangements were evolved more fully and the archeological detail needed to be 'correct' in every respect.

<sup>29</sup> See Chapter I.

<sup>30</sup> St. Alkmund's, Shrewsbury, 1795. See N. Pevsner, Pioneers of Modern Design, 1966, p. 130. St. Peter's, Adderley, Shropshire, c. 1795. See Marcus Whiffen, Early Iron I-Window Tracery, Architectural Review, August 1949, pp. 126-7 Eccleston Church Cheshire by William Porden, 1809. See E. D. Colley op. cit., p. 35. Rickman visited Porden's church, and Eaton Hall where gothic iron windows were being used. See E. D. Colley op. cit., p. 36.

<sup>31</sup> J. A. Picton, op. cit., Vol. II, p. 370.



Plate 23. St. George's Everton, Liverpool by Thomas Rickman and John Cragg, 1813-14. Interior view of ironwork to gallery and nave roofs.

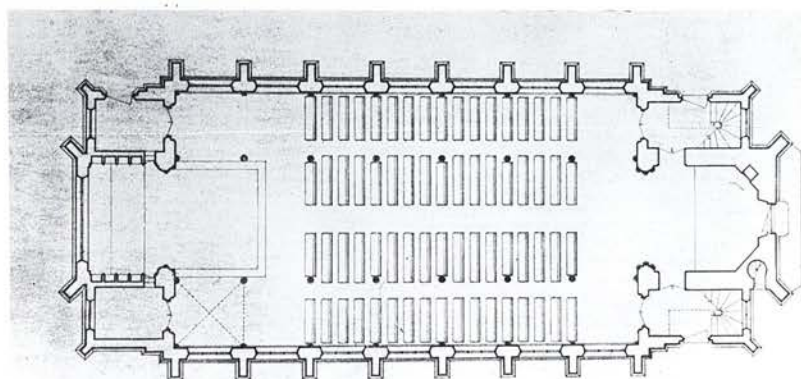
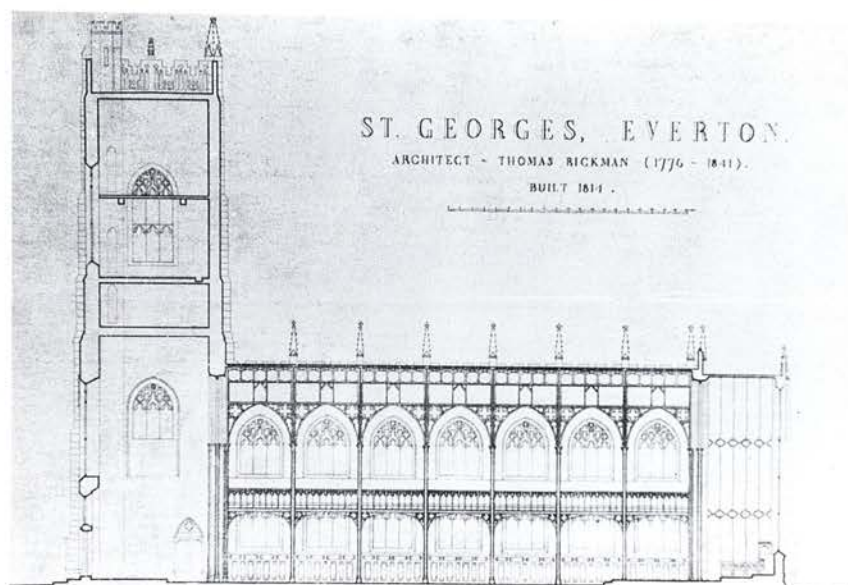


Plate 24. St. George's Everton. Plan and long section.



The exterior of St. George's gives only the slightest indication of its interior; the walls are of local stone and iron is used only in the tracery in the large 'Perpendicular' windows.

In Rickman and Cragg's next church building project, however iron was to be used extensively inside and outside. This was the church of St. Michael's-in-the-Hamlet, preliminary designs for which had been prepared in 1812. It was built in 1814-15 and the design is very closely related to a patent which Cragg took out in November 1813.<sup>32</sup> (See Plate 25). The drawing accompanying the patent shows the unmistakeable hand of Rickman.<sup>33</sup> and displays many of the iron elements used in St. Michael's. The columns, windows, traceried brackets, buttress caps, parapet and pinnacles all appear in very similar form in the church. However the one small difference between the patent and the building was the system of walling. In St. Michael's, solid masonry walls were used; the patent however shows a system of slate-faced walls. This was the system that appears to have developed from Cragg's earlier patent for iron and slate roofing.<sup>34</sup> The patent does give

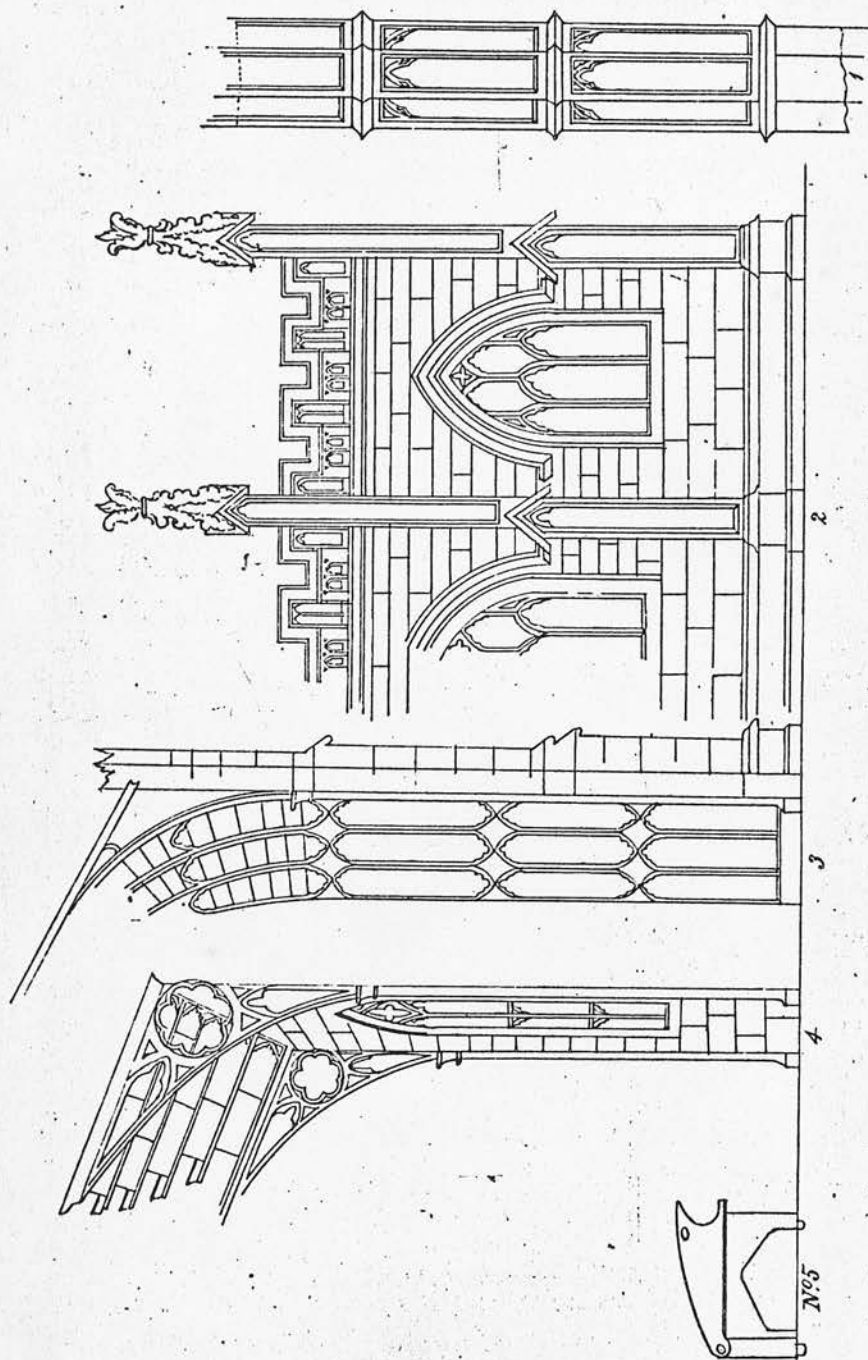
<sup>32</sup> No. 3761, 29th November, 1813. Facing walls of Gothic or other structures with slates, secured by mouldings, grooves and ties of cast iron, so as to have (when sanded) the appearance of finely wrought stone work; also ceilings of the same materials; capping buttresses in Gothic architecture with pinnacles of cast-iron; spiral stair of cast-iron, for the interior of a tower, wall, or turret. This patent is discussed in, Practical Economy or the application of modern discoveries to the purposes of modern life, 1821, pp. 22-3.

<sup>33</sup> The strange style of perspective in Fig. 4 is exactly similar to the drawings which Rickman prepared for the revised 4th edition of An Attempt to discriminate the styles of Architecture in England in 1835.

<sup>34</sup> See note 24.

(SHEET)

A.D. 1813. Nov. 29. N.º 3761.  
CRAGG'S SPECIFICATION.



Drawn on Stone by J. J. Ry. & Sons.

LONDON: Printed by GEORGE EDWARD EYRE and WILLIAM SPOTTISWOODE,  
Printers to the Queen's most Excellent Majesty. 1856.

Plate 25. Drawing from John Cragg's Patent No. 3761, 29th November 1813.



further evidence of Cragg's role as co-designer with Rickman particularly in St. Michael's.

The plan is similar to the Everton church but on a smaller scale and with no aisle galleries. The aisles are roofed at a lower level than the nave, producing clerestory windows. (See Plates 26 and 27). The interior, though more modest, displays many similar details to St. George's; the East window has identical tracery except that in St. Michael's it is cut off at the level of the first transom.

The exterior is in sharp contrast to the Everton church. The exterior wall is faced in cast iron up to the sill level. Above, red brick walls and buttresses are carried up to the iron parapet and pinnacles. The nave walls at clerestory level are constructed of a framework of iron, with iron cladding panels between the 'Early English' iron tracery windows. (See Plate 28).

More or less every element that could benefit from repetitive casting was made in iron in St. Michael's. Cragg's motive for this use of iron is given in his patent: "These adornments ... when constructed of cast iron, painted soon after they are cast, when they are put up and then sanded, will have all the effect of the most beautiful carvings of stone, with far greater durability than the friable stone in common use finely cut, and exposed to the variations in climate".<sup>35</sup>

In 1816, the third Rickman and Cragg iron church was built. St. Philips Hardman Street, a modest brick building rendered with stucco, made far less extensive use of iron. "The windows are of the

<sup>35</sup> Patent No. 3761, op. cit., p. 3.

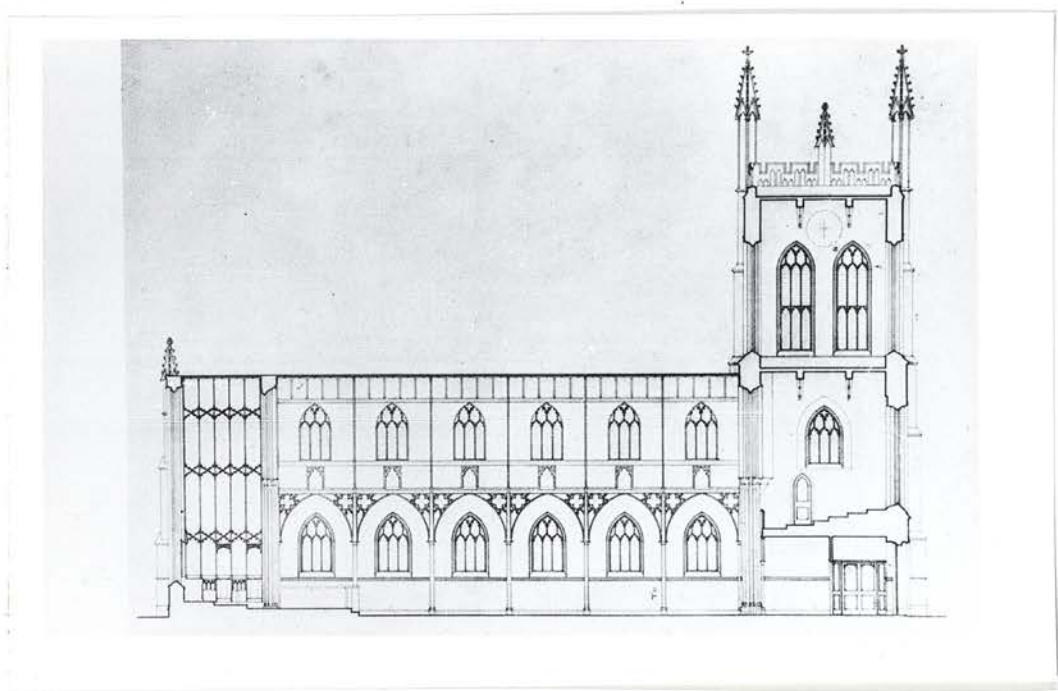


Plate 26. St. Michael's in the Hamlet, Liverpool by Thomas Rickman and John Cragg, 1814-15. Long section.



Plate 27. St. Michael's in-the-Hamlet. Interior view of the nave.



Plate 28. St. Michael's in-the-Hamlet. Exterior view of nave and aisles.



depressed Tudor arch form, with slender cast iron tracery. Hollow octagonal turrets are carried up at the angles, crowned with spirets, ornamented with cast-iron crockets. The absence of any central or aspiring feature to carry the eye upwards is the great defect in the external design of this building, which is a sort of feeble imitation of Kings College Chapel, Cambridge."<sup>36</sup> (See Plate 29).

In 1817, Rickman opened an architect's office in Liverpool and in the same year met the Bishop of Chester, G.H. Law, who was appointed to H.M. Commission for Building New Churches in 1818. The Bishop wrote in August 1818 to Lord Liverpool, "In order that no time might be lost in fixing a plan upon which the new churches might be built in the Diocese of Chester, I have procured the accompanying design from Mr. Rickman a very able architect in Liverpool."<sup>37</sup> Rickman's design was put before the Commission and then referred to the Crown Architects<sup>38</sup> for scrutiny. In his notes that accompany the design, he makes specific reference to the use of iron and more especially to the economy of repetition. "I must notice the cost of patterns for the windows and other cast iron work. These, if only one church were to be erected and the patterns then become useless might perhaps cost £150; but as many churches are to be built, the windows and other things being carefully prepared

<sup>36</sup> J.A. Picton, op.cit., Vol. II, pp. 248-9.

<sup>37</sup> The Church Commissioners for England, File 21744, pt. I. Quoted in M.H. Port, Six Hundred New Churches, 1961, p. 50.

<sup>38</sup> These were John Nash, John Soane and Robert Smirke. All three submitted sample designs to the Commission employing iron pillars as supports to galleries. See M.H. Port, op.cit., pp. 38-40, and Rhodri Liscombe, Economy, character and durability: specimen designs for the Church Commissioners, 1818, Architectural History, Vol. 13, 1970, pp. 43-57.



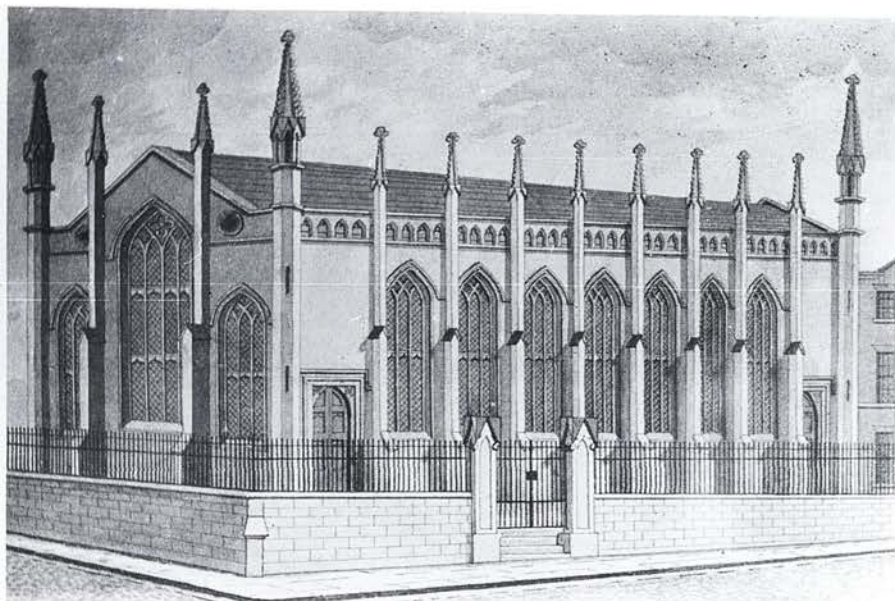


Plate 29. St. Philip's, Hardman Street, Liverpool, by Thomas Rickman and John Cragg, 1816.

to be generally useful, the cost of patterns might be reduced to a trifle for each church".<sup>39</sup>

After extended deliberations, the Commission decided against adopting Rickman's standard plan, but the friendship and patronage of the Bishop of Chester did bring a series of commissions over the next twenty years.

Rickman built no less than twenty-four churches for the Commissioners between 1819 and 1838. Seven of these<sup>40</sup> employed iron, using standard patterns for pillars, gallery supports, gallery panels, doors and pew decoration.

A case for the radical use of iron for churches sponsored by the Commission was also put by an unidentified writer to the Gentleman's Magazine.<sup>41</sup> It was argued that the cheapness of labour in the Middle Ages had enabled the architects to produce stupendous ornamental Gothic buildings, and that the present day factories could produce the same quality of ornament at a trifling expense in cast iron. "There is scarcely an ornament or necessary part but what might be cast at our iron foundries, even to the highest wrought filigree Gothic: and as nearly all the tracery and ornaments in this style are produced

<sup>39</sup> Public Record Office, Works 6/183, 1, no. 18. Quoted in M. H. Port, op. cit., p. 66.

<sup>40</sup> St. George's, Birmingham, 1819-22; St. George's Barnsley, 1821-2; St. Peter's Preston, 1823-5; St. George's, Chorley, 1821-4; St. Paul's Preston, 1825; Holy Trinity, Carlisle, 1828-30; Christ Church Carlisle, 1828-30.

<sup>41</sup> W. F. W., Hints respecting New Churches, Gentleman's Magazine, December 1818, pp. 506-8.

by a repetition of a few simple parts, the plan would be found perfectly practicable."<sup>42</sup>

It was further argued that the buildings would be fireproof - a rather rash claim - and, like Cragg, that the sharpness of detail would not be subject to the decay that stone would suffer.

However this plea, like Rickman's, was neither heard nor accepted. The Commissioners churches only used iron in a fairly conventional way as structural supports and, from time to time, for window tracery and internal detail.

With the increasing knowledge and study of medieval church building in the 1830's, and the rise of the influence of Pugin and the Camdenians, the use of iron in church building fell into disrepute and did not really re-appear, with a few exceptions, until the 1850's.

### CHAPTER III

Early 'Ferro-vitreous' Art - horticultural buildings in iron and glass  
(1863-27)

<sup>42</sup> Ibid., p. 507.

to describe that class of construction which originated in the building for the Great Exhibition. The origins of this mode of construction lay in the substitution of iron for timber in horticultural buildings in the early years of the 19th century. The earliest instance would seem to be Humphry Repton's design for a pavilion and greenhouse at Plas Newydd, Anglesey. (See Plate 39) published in his 'Observations on the Theory and Practice of Landscape Gardening'. In this he describes the building and his choice of style. "At Plas-Newydd, where the house partakes of a Gothic character<sup>2</sup>, I suggested the addition of a green-house, terminating a magnificent avenue through a long line of principal apartments. The hint for this model is taken from the chapter-rooms to abais of our cathedrals, where an octagon

### CHAPTER III

Early 'Ferro-vitreous Art' : horticultural buildings in iron and glass (1803-27)

glass, while the side window-frames might be removed entirely in summer, making a beautiful edifice at that season, when the plants being removed, a green house is generally a deserted and unsightly object."<sup>3</sup>

<sup>1</sup> J. Ferriessan, *History of the Modern Styles of Architecture*, 1842, p. 487.

<sup>2</sup> Design by Joseph Potter (the elder) for the Earl of Oxford, c. 1803. See *Colvin* p. 472.

<sup>3</sup> Humphry Repton, *Observations on the Theory and Practice of Landscape Gardening*, 1803, pp. 101-6.

James Fergusson used the term "Ferro-vitreous Art"<sup>1</sup> to describe that class of construction which culminated in the building for the Great Exhibition. The origins of this mode of construction lay in the substitution of iron for timber in horticultural buildings in the early years of the 19th century. The earliest instance would seem to be Humphry Repton's design for a pavilion and greenhouse at Plas Newyd, Anglesey, (See Plate 30) published in his 'Observations on the Theory and Practice of Landscape Gardening'. In this he describes the building and his choice of style. "At Plas-Newyd, where the house partakes of a Gothic character<sup>2</sup>, I suggested the addition of a green-house, terminating a magnificent enfilade through a long line of principal apartments. The hint for this model is taken from the chapter-rooms to some of our cathedrals, where an octagon roof is supported by a slender pillar in the middle, and if this were made of cast iron, supporting the ribs of a roof of the same material, there would be no great impropriety in fixing the interstices with glass, while the side window-frames might be removed entirely in summer, making a beautiful pavilion at that season, when, the plants being removed, a green house is generally a deserted and unsightly object."<sup>3</sup>

<sup>1</sup> J. Fergusson, History of the Modern Styles of Architecture, 1862, p. 482.

<sup>2</sup> Design by Joseph Potter (the elder) for the Earl of Uxbridge, c. 1800 See Colvin p. 470.

<sup>3</sup> Humphry Repton, Observations on the Theory and Practice of Landscape Gardening, 1805, pp. 105-6.



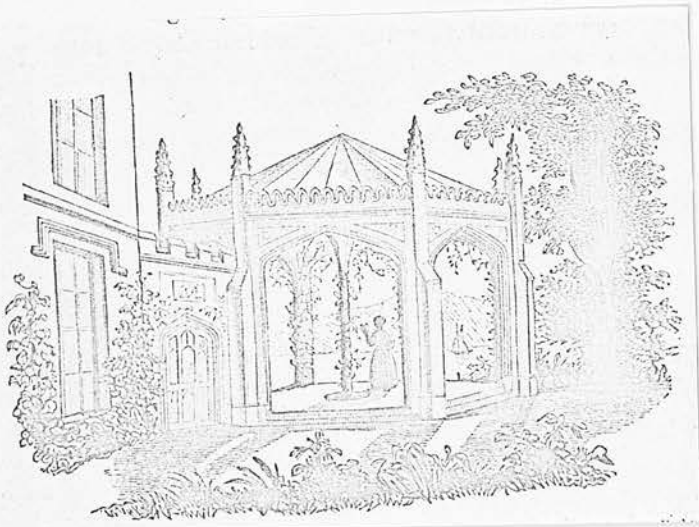


Plate 30. Design for a Pavilion and Greenhouse, Plas-Newydd,  
Anglesey, by Humphry Repton, before 1803.

Repton also seems to have the distinction of being the first author to discuss the aesthetic problems of the introduction of this new material into architecture - a problem which was to be endlessly argued over later in the century. In a footnote to the description of the greenhouse at Plas Newydd he refers to a conversation with the late Earl of Orford at Strawberry Hill on the subject of the revived Gothic style. The "error, in the imitators of Gothic, often arises from their not considering the difference of the materials with which they work: if in the mullions of a window, or the ribs of a ceiling they copy in wood or plaster, ornaments originally of stone, they must preserve the same massive proportions that were necessary in that material or they must paint it like wood, and not like stone; but if the architects of former times, had known the use we now make of cast-iron, we should have seen many beautiful effects of lightness in their works; and surely in ours, we may be allowed to introduce this new material for buildings, in the same manner that we may fairly suppose they would have done, had the invention been known in their time: but wherever cast iron is used in the construction, it ought to be acknowledged as a support, either by gilding, or bronze, or any expedient that may shew it to be metal, and not wood or stone, otherwise it will appear unequal to its office."<sup>4</sup>

In the same year that the 'Observations' were published, Repton, as part of his improvements for the Prince of Wales at Carlton House,<sup>5</sup>

<sup>4</sup> Ibid., p. 106.

<sup>5</sup> Dorothy Stroud, Humphry Repton, 1962, p. 131 and p. 115.

produced a design for a conservatory in iron and glass.<sup>6</sup> (See Plate 31). The building was not carried out but from this drawing it is possible to appreciate the "beautiful effects of lightness" that Repton envisaged.

In this drawing the profuse foliage rather obscures the details of the ironwork, but the truss design is obviously reminiscent of the circular rings of iron in the Sunderland Bridge. Little indication is given of the arrangement of glazing bars, a subject which was to effect radical changes in hothouse design during the next twenty years.

The use of iron for glazing bars would seem to have been fairly common in the first decade of the 19th century. Walter Nicol,<sup>7</sup> however, along with many other horticulturists was extremely hostile to the use of iron. "On account of the high price of timber, some are now constructing the framing of hot-houses of cast iron. I would beg to remind such that there is nothing so prejudicial to vegetation as the dripping of rusted iron; and would advise that the frames be well painted and frequently painted in order to prevent the bad effects of irony water falling on the foliage and fruit. I am of opinion, however, that iron framed hot-houses will soon get out of fashion. From the quantity of water that must be used, in order to keep the plants in health, the frames must be often moistened and will corrode."<sup>8</sup>

<sup>6</sup> Ibid., p. 131.

<sup>7</sup> A Scotch horticultural architect, who was at one time gardener to the Marquis of Townsend at Rainham Hall, Suffolk, and to General Wemyss at Weymss Castle, Fife. From 1797 he settled in Edinburgh and subsequently became Secretary of the Caledonian Horticultural Society.

<sup>8</sup> Walter Nicol, The Gardener's Kalender, Edinburgh, 1810, p. 288.

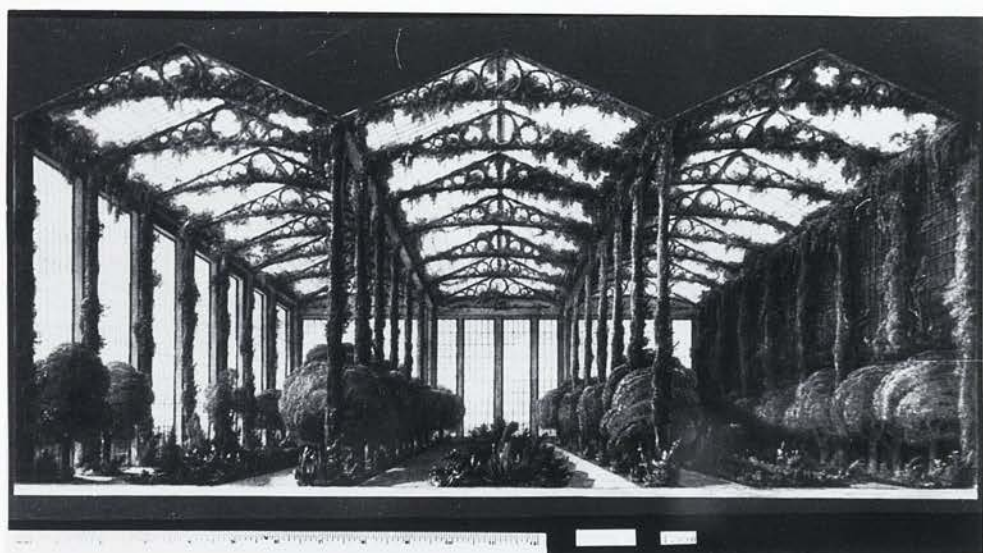


Plate 31. Design for a Conservatory, Carlton House, London,  
by Humphry Repton, 1803.

In the early years of the 19th century a very large body of literature on hot-house design began to appear<sup>9</sup>, much of it devoted to the form of glazing. One paper however was to have a remarkable effect on the subsequent design of hot-houses and also to the more extensive use of iron. This was Sir G. S. Mackenzie's paper presented to the Horticultural Society of London in 1815.<sup>10</sup>

Mackenzie proposed a form which would "receive the greatest possible quantity of the sun's rays, at all times of the day, and at all seasons of the year."<sup>11</sup> To this end he suggested a forcing house in the form of a semi-dome. (See Plate 32). Mackenzie chose cast iron as the material for the ribs of the semi-dome but suggested that it could also be constructed in wood if necessary. Mackenzie does not seem to have been aware of the structural advantage of using iron which meant that the iron and glass in combination became a structural skin.

John Loudon was the first man to realise the importance of Mackenzie's proposals. He immediately set to work to develop the idea further and his first step was to design a wrought-iron sash bar<sup>12</sup> - the change to wrought iron simplified manufacture - and

<sup>9</sup> The best general account of the evolution of hot-house design is given in Kenneth Lemmon, The Covered Garden, 1962.

<sup>10</sup> Sir G. S. Mackenzie, On the Form which the Glass of a Forcing House ought to have, in order to receive the greatest possible quantity of Rays from the Sun, Transactions of the Horticultural Society of London, Volume II, 1817, pp.171-7.

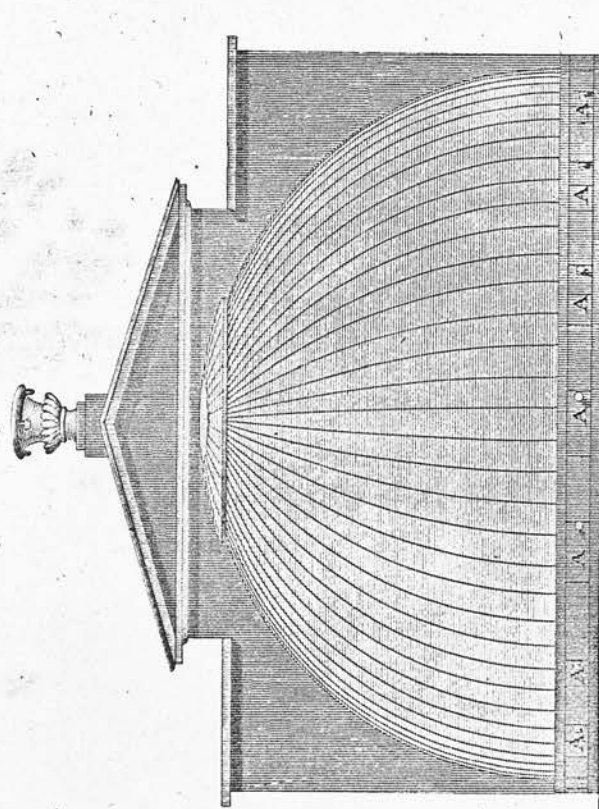
<sup>11</sup> Ibid., p.173


<sup>12</sup> Illustrated in J. C. Loudon, Encyclopaedia of Gardening, 4th Edition, 1826, p.314. A specimen of the glazing bar was presented to the London Horticultural Society in May 1816.



# Elevation of the Front.

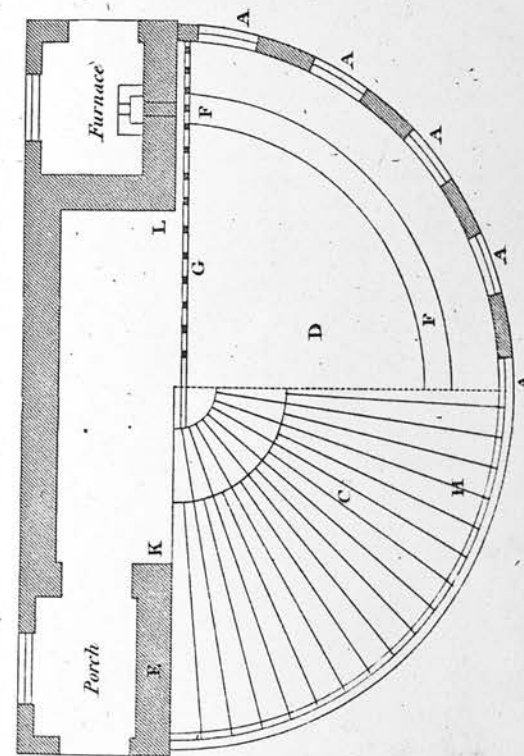
Fig. 1.



- A Sliding shutters in low wall to admit Air.
- B Shutters along the top of back wall to open and shut on pivots with a cord. Larger openings may be made by means of windows in the back wall.
- C Half the plan of the glass cover formed of cast iron astragals  $2\frac{1}{2}$  inches from front to inside and  $\frac{1}{2}$  inch thick on which the glass is fixed thus  glass.
- D Half the plan showing the flue F going round to E and out at the vase at top.
- G Trallage for vines with an opening in the centre 6 ft. 3 in. or 3 to allow a person to pass.
- H Cast iron astragals glazed.

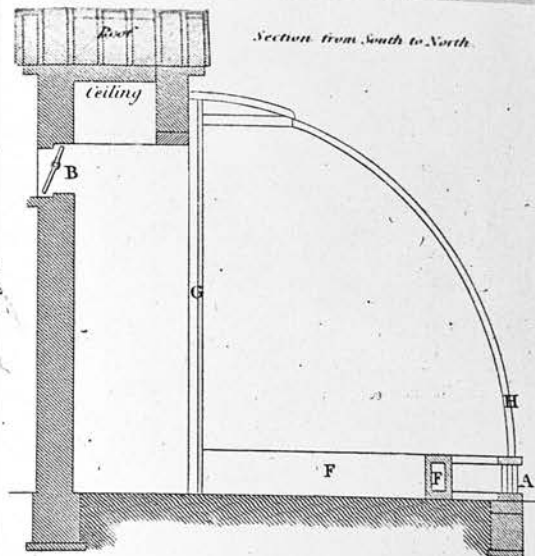
# Plan of the House.

Fig. 2.



The roof of the Porch & Furnace will be about 8 feet from the ground.

Fig. 3.



Scale of Feet.

during 1817 to have constructed, in the gardens of his own house in Bayswater, "a considerable erection of glass roofs."<sup>13</sup> (See Plate 33). This appears to have been the first example of curvilinear glass roofing to actually be constructed and was designed to show that there was a wide variety of forms that could be achieved by the use of the iron sash bar.

During the time that the Bayswater glass roofs were under construction, Loudon was writing a book on hothouse design<sup>14</sup> which closely related to the experimental roofs. In this he gives two cardinal reasons for the use of iron. Firstly "the grand advantages of metallic astragals and iron rafters in glass roofs, is the increase thereby obtained of transparent surface"<sup>15</sup>. Secondly, he favoured the solid wrought iron astragal because it was "stronger and better adapted for curved work and there being less labour, somewhat cheaper"<sup>16</sup>.

In 1818 the right of invention of Loudon's iron sash bar was transferred to W. & D. Bailey of Holborn, a firm specializing in the construction of horticultural buildings. William Bailey subsequently

<sup>13</sup> Ibid., p. 314

<sup>14</sup> J. C. Loudon, Remarks on the Construction of Hothouses, 1817. In the following year two further works by Loudon on the subject were published: Sketches of Curvilinear Hothouses and A Comparative View of the Common and Curvilinear Modes of Roofing Hot-houses.

<sup>15</sup> J. C. Loudon, Remarks etc., p. 35.

<sup>16</sup> Ibid., p. 78.

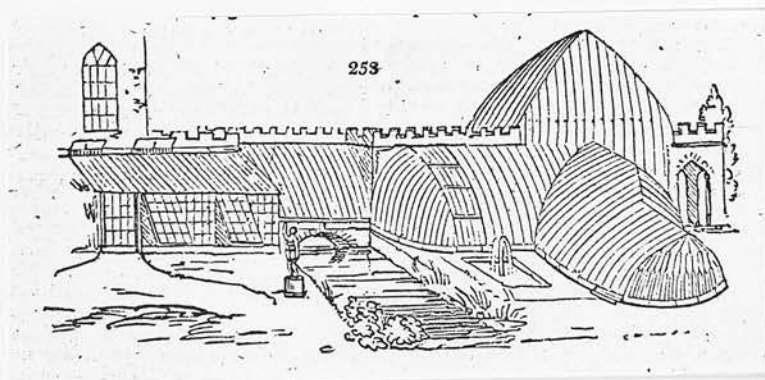


Plate 33. Curvilinear Hot-houses, Bayswater, by J. C. Loudon, 1818.

took out a patent<sup>17</sup> and over the next ten years constructed no less than twenty five hothouses on the curvilinear principle using the wrought iron bar.<sup>18</sup> A typical example was the orangery erected at Rochetts in Essex for the Earl of St. Vincent. (See Plate 34). It was a 40 feet diameter semi-dome very closely reminiscent of Mackenzie's proposals.

The most spectacular example was a conservatory of 100 feet diameter erected in 1827 at Bretton Hall in Yorkshire. (See Plate 35). Loudon describes it as "constructed entirely of cast and wrought iron; all the perpendicular supports being of the former and all the sash bars composing the ribs of the roof of the latter material ... The cost for the ironwork alone was between £3,000 and £4,000. It is worthy of remark, that there were no rafters or principal ribs for strengthening the roof beside the common wrought iron sash-bar, which is two inches deep and half an inch thick in the thickest part, and weighs only about one pound to the lineal foot. The upper dome had an independent support from cast iron pillars. When the iron-work was put up, before it was glazed, the slightest wind put the whole of it in motion from the base to the summit; and so much alarm did this create in the party for whom it was put up,<sup>19</sup> or their agents,

<sup>17</sup> No. 4277, 11th July 1818. Sashes, skylights and frames for containing glass and for making roofs of houses and various other buildings.

<sup>18</sup> J. C. Loudon, Encyclopaedia etc., p. 310, Section 1587.

<sup>19</sup> "the munificent patroness of gardening and botany, Mrs. Beaumont"  
See (J. C. Loudon) The Gardener's Magazine, Vol. VIII, 1832, p. 607.



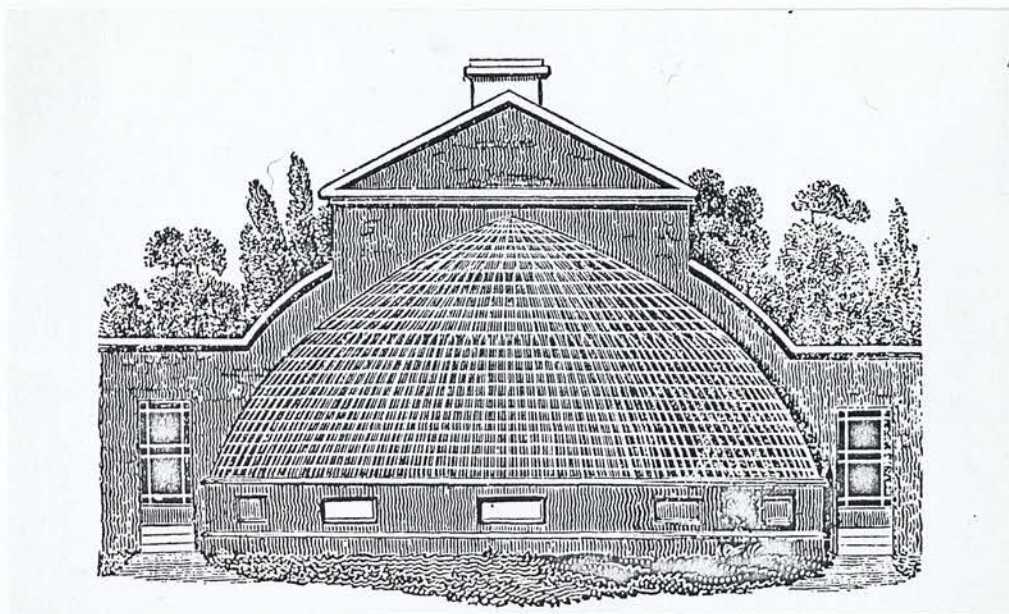


Plate 34. Orangery at Rochetts, Essex, designed and built by  
W. and D. Bailey before 1824.

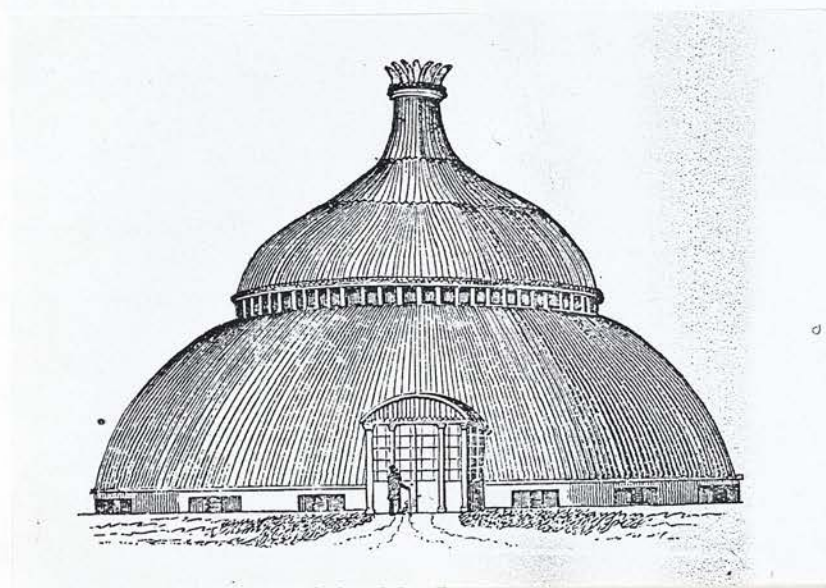


Plate 35. Conservatory at Bretton Hall, Yorkshire, designed and  
built by W. and D. Bailey 1827.



that the contractors for the work, Messrs. W. and D. Bailey of Holborn, London, were obliged to covenant to keep it in repair for a certain number of years. As soon as the glass was put in, however, it was found to become perfectly firm and strong, nor did the slightest accident from any cause, happen to it, from the time it was completed in 1827, till on the death of Mrs. Beaumont, in 1832 it was sold by auction, and taken down. It brought only about £560, though it is believed to have cost in all upwards of £14,000".<sup>20</sup>

On spite of the great structural achievement of the Bretton Hall conservatory, from a horticultural point of view it was a great failure. It was impossible to keep a building of so great a volume and height at an even temperature,<sup>21</sup> and this sad fact undoubtedly led to its premature demolition.

The high cost of this building was, of course, partly due to its size but the cost of such a building at that date was mostly attributable to the very high price of glass. Glass was heavily taxed and it was only in 1845 when the tax was repealed<sup>22</sup> that a conservatory or greenhouse could become, instead of an exclusive luxury, an inevitable addition to any well-appointed house.

<sup>20</sup> J. C. Loudon, An Encyclopaedia of Cottage, Farm and Villa Architecture and Furniture, 1833, p. 980. See also (J. C. Loudon), The Gardener's Magazine, Vol. V, 1829, p. 680-4.

<sup>21</sup> The gardener at Bretton Hall at the time was a Mr. Robert Marnock, whose detailed account of the difficulties in heating the conservatory is given in Charles M'Intosh, The Book of the Garden, 1853, Volume 1, pp. 129-30.

<sup>22</sup> For a detailed account of the changes in glass prices and its effect on hothouse design, see Kenneth Lemmon, op. cit. pp. 87-9.

Up to the 1830's, the technique of iron and glass construction had been used exclusively in horticultural buildings. By the mid 1830's they began to be applied to other building types - markets, exchanges, railway termini and exhibition structures. All were buildings which now epitomise Victorian commercial architecture. They had in common a need for large space, and for roof-lighting, as they usually had deep plans. The use of iron structures with glass roofs was an inevitable choice.

The need for a large, uninterrupted floor space was not new, but before 1830 the problem had been solved generally by either masonry vaults or domes, or timber structures. The first building to use iron to this end was Charles Fowler's roof of 1835

# CHAPTER IV

The climax of 'Ferro-vitreous Art': conservatories, markets, railway termini, exchanges, museums and exhibition buildings (1835-62)

By the mid 1830's, which made extensive use of iron. The only precedent in market building that Fowler could examine was St. John's Market, Liverpool<sup>3</sup>, but this was in timber.

<sup>1</sup> Domes constructed of hollow fire-clay pots had been used by James in his rebuilding of the Bank of England from 1792 onwards. Because of the reduction in weight the spans could be greater than solid vaults would have allowed. See H. R. Stead & F. R. Torbury, The Bank of England, 1910.

<sup>2</sup> Completed in 1830. See Charles M'Jordan, The Book of the Garden, 1830, Vol. 1, p. 352, and Plate XVI.

<sup>3</sup> Designed by John Fowler (Senior & Junior) 1829-4. The market covered an area of 550 feet by 125 feet, and had columns at about 70 feet centres. See J. A. Pictor, Memoirs of Liverpool, 2nd edition, 1875, Vol. II, p. 173.

Up to the 1830's, the techniques of iron and glass construction had been used exclusively in horticultural buildings. By the mid 1830's they began to be applied to other building types - markets, exchanges, railway termini and exhibition structures. All were buildings which now epitomise Victorian commercial architecture. They had in common a need for large spans, and for roof lighting, as they usually had deep plans. The use of iron structures with glass roofs was an inevitable choice.

The need for a large, uninterrupted floor space was not new but before 1830 the problem had been solved generally by either masonry vaults<sup>1</sup> or domes, or timber structures. The first building to use iron to this end was Charles Fowler's roof of 1835 in the Hungerford market. Fowler by this time had successfully completed a large conservatory for the Duke of Northumberland at Syon House<sup>2</sup> which made extensive use of iron. The only precedent in market building that Fowler could examine was St. John's Market, Liverpool<sup>3</sup>, but this was in timber.

<sup>1</sup> Domes constructed of hollow fire-clay pots had been used by Soane in his rebuilding at the Bank of England from 1792 onwards. Because of the reduction in weight the spans could be greater than solid vaults would have allowed. See H. R. Steele & F. R. Yerbury, The Old Bank of England, 1930.

<sup>2</sup> Completed c. 1830. See Charles M'Intosh, The Book of the Garden, 1853, Vol. I, p. 368, and Plate XVI.

<sup>3</sup> Designed by John Foster (Senior & Junior) 1820-4. The market covered an area of 550 feet by 135 feet, and had columns at about 30 feet centres. See J. A. Picton, Memorials of Liverpool, 2nd edition, 1875, Vol. II, p. 173.

The conditions at Hungerford excluded the use of timber, as the structure had to avoid being "rendered impure or offensive by absorbing any portion of the fishy matter, either in substance or exhalation."<sup>4</sup> The position of the fish market in the lower quadrangle surrounded by lofty stone collonades necessitated "that the covering should be so constructed as to admit the greatest possible quantity of light and air."<sup>5</sup>

To answer these requirements, Fowler designed a free standing iron structure of exceptional lightness and elegance. (See Plates 36 & 37). The principle span of 32 feet was carried by a portal frame, jointed at mid-span, with 6 feet cantilevers on the outside, producing the very distinctive 'double butterfly' form. In order to make a secure joint at the centre, the main frame was extended upwards to give a greater area of contact. This joint<sup>6</sup> was made by a most unorthodox technique. At the bottom it was secured by a "wrought iron collar put on when red hot, so that in cooling, the contraction tightens and completes the union."<sup>7</sup> The apparent awkwardness of the central joint was turned to benefit as the extra height enabled Fowler to achieve clerestory glazing.

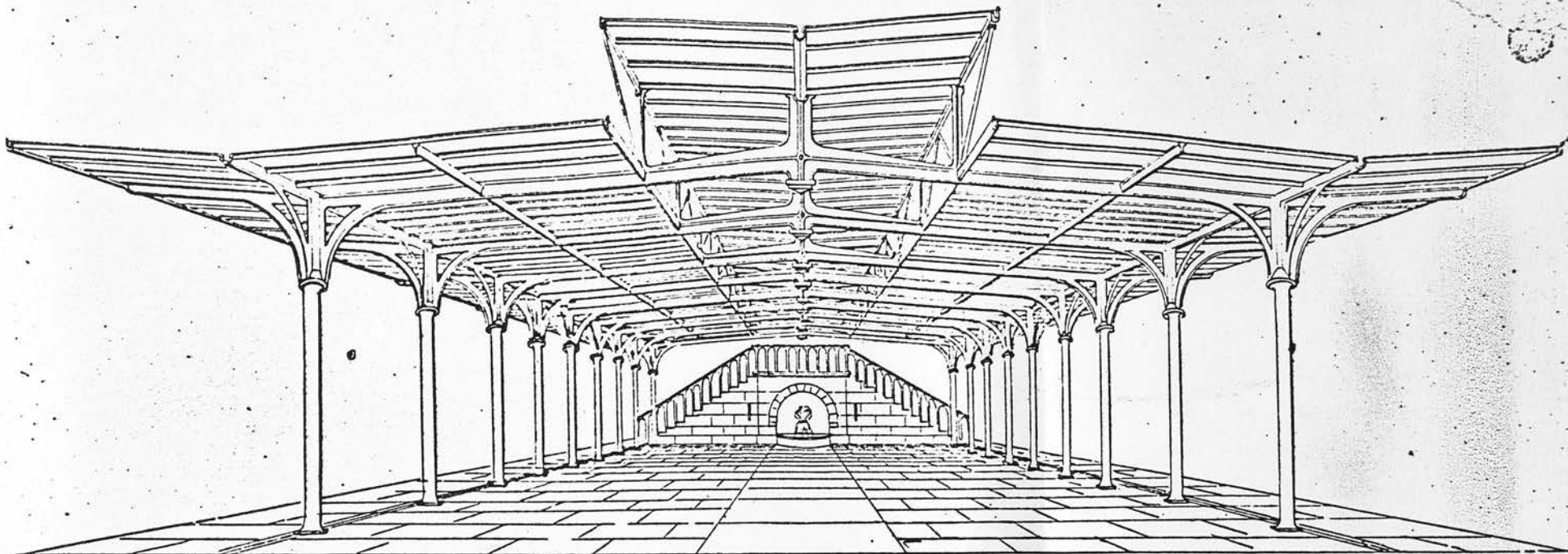
<sup>4</sup> Charles Fowler, Metal Roof at Hungerford Market, Transactions of the Institute of British Architects, Vol. I., 1836, p. 44.

<sup>5</sup> Ibid., p. 44.

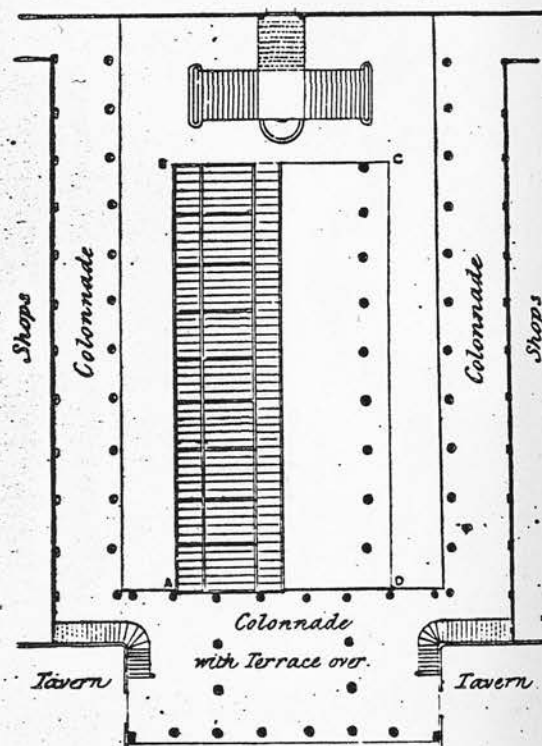
<sup>6</sup> Messrs. Bramah (the contractors) made experiments on the effect of a central joint in the portal by using models, and as a result the size of the ribs were increased.

<sup>7</sup> Charles Fowler, op. cit., p. 45.

# HUNGERFORD MARKET.



PLAN AND VIEW OF THE METAL ROOF IN THE CENTRE OF THE FISH MARKET, ERECTED A.D. 1835. A.B.C.D. Area of Roof.



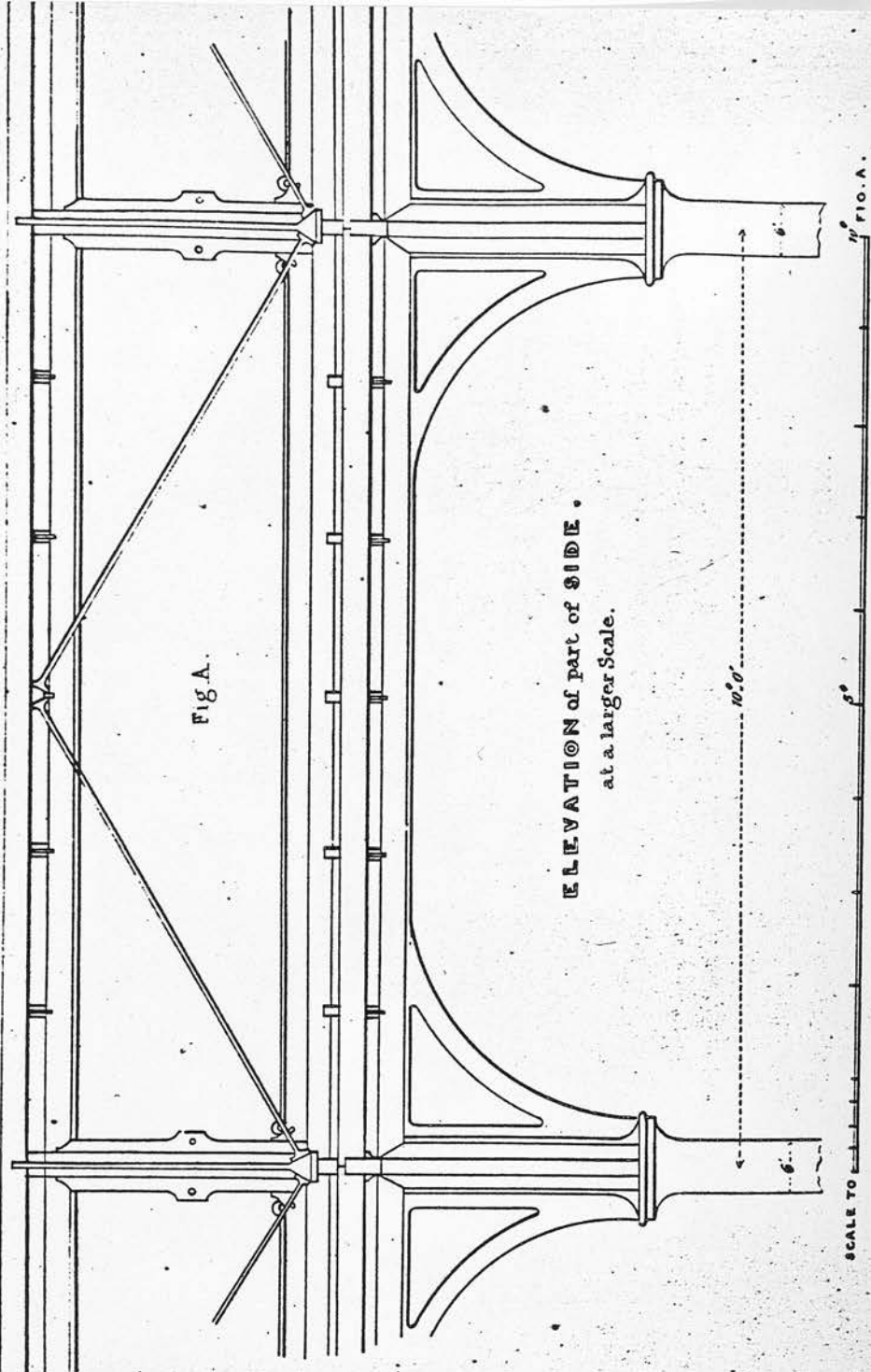
*Two & Eighteen Feet to the King.*

C. FOWLER, ARCHT.  
ERECTED A.D. 1835.

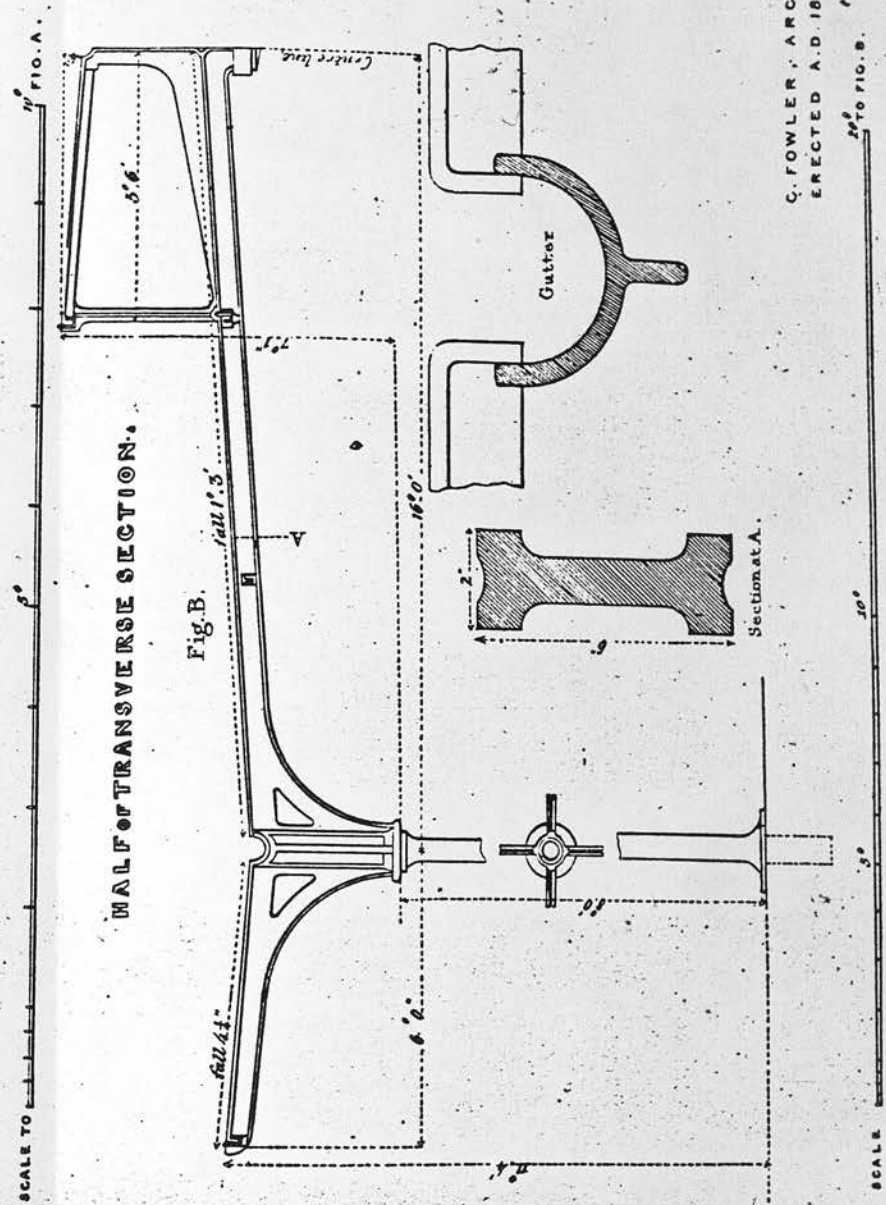
Transactions of the Institute of British Architects 1836.



MUNGERFORD. MARKET  
Roof in the Centre of Fish Market.



HALF-TRANSVERSE SECTION.



C. FOWLER, ARCHT.  
ERECTED A.D. 1835.

Diagonal bracing in the direction of the secondary span was fitted into the depth of the clerestory glazing. (Fig.A, Plate 37). The falls on the side roofs allowed rainwater to drain to the gutters over the lines of the columns. The water was then carried down each alternate column, which acted as a rainwater pipe. (Fig.B, Plate 37). How the water from the gutter in the centre of the raised portion of the roof was drained away Fowler omits to explain.

The detailing of the building is masterly. Complicated joints are detailed in such a way as to give the structure a simple elegance. There is nowhere any attempt to add any decorative device. The evidence of this building certainly leads one to agree with Loudon who described Fowler as "one of the few modern architects who belong to the School of Reason and who design buildings on fundamental principles instead of antiquated rules and precedents".<sup>8</sup>

At exactly the same time as Fowler's roof was being constructed, work started on the train sheds at the first London railway terminus to be built. The Euston terminus had been planned by Robert Stephenson but responsibility for the design of the train sheds was given to Charles Fox,<sup>9</sup> then a resident engineer to the London & Birmingham Railway.

<sup>8</sup> The Architectural Magazine, Vol. V, 1838, pp.676-7. Quoted in Jeremy Taylor, Charles Fowler (1792-1867) a centenary memoir, Architectural History, Vol. 11, 1968, p. 59.

<sup>9</sup> Later Sir Charles Fox, whose important contribution to the Great Exhibition building is discussed below.

It was the first railway station to have a complete iron structure for its sheds, and the wrought iron trusses established a prototype used many times afterwards in a wide variety of buildings. (See Plate 38). The 40 feet trusses spanned over the tracks and were supported on slender cast iron columns, which again served as rainwater pipes.<sup>10</sup> The roofing material was timber (presumably with a zinc or lead covering) : roof lights were used only on the span adjacent to the waiting rooms and booking offices. Sparing use of glass was to be expected as glass was still taxed heavily. The secondary span consisted of arched bressummers 20 feet long, of a pattern reminiscent of the standard type of rib in cast iron bridges of the 1790's.

Fox's iron work appears rather bald and plain in comparison with Fowler's work, and lacks the refinement so apparent in the Hungerford roof. And as with so many other railway termini that were to follow, the architect had no hand in the design of the train shed,<sup>11</sup> which was considered to be a structure of such self-evident utility that it was left in the hands of an engineer.<sup>12</sup>

<sup>10</sup> A detailed drawing of these trusses can be found in Public Works of Great Britain, edited by F. W. Simms, 1838, Plate VII, together with a description on p. 3.

<sup>11</sup> Philip Hardwick designed the famous Portico and Lodges at Euston (1835-40). See Survey of London, Vol. XXI, 1949, p. 107 ff.

<sup>12</sup> A notable exception was M. D. Wyatt's and I. K. Brunel's joint design of the train shed at Paddington in 1854.

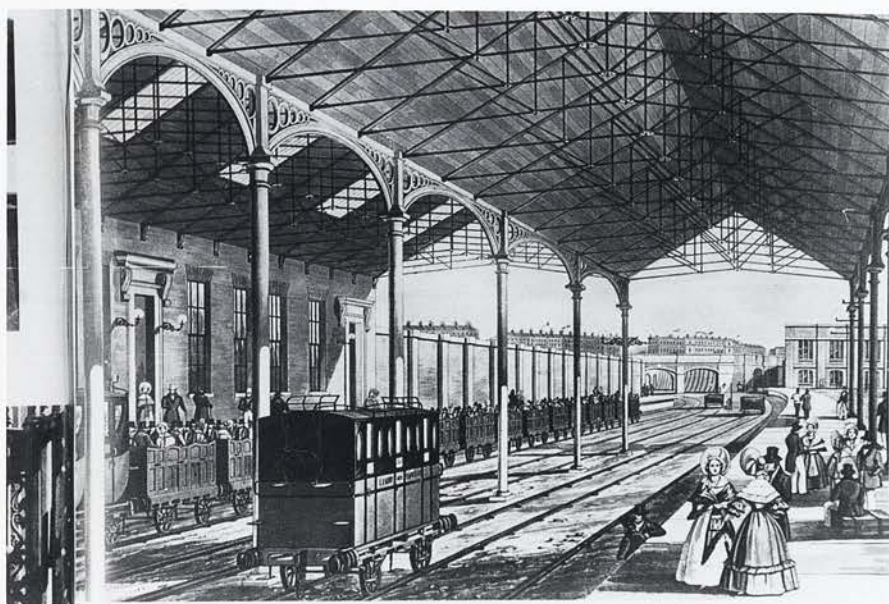


Plate 38. Train sheds, Euston, by Charles Fox, 1835-9.



The next development in ferro-vitreous building concerns one which paradoxically sought to limit the use of iron externally. This was Joseph Paxton's Great Stove at Chatsworth. (See Plate 39). During the early 1830's at Chatsworth he had made several experiments with 'ridge and furrow glazing' - an idea which was set out clearly in Loudon's 'Remarks on the Construction of Hothouses' in 1817. It seems that Loudon never utilized this idea but preferred smooth profile glazing with iron astragals. Paxton was never in favour of iron glazing bars. He preferred the lightness and cheapness of timber bars. By means of the 'ridge and furrow' profile, greater transmission of sunlight was obtained, even though the timber glazing bar might be thicker. By the time work started in 1836 on the Great Stove, Paxton had successfully constructed buildings of curvilinear construction and he had evolved the main essentials of his system of 'ridge and furrow' glazing, including a machine to manufacture his famous 'Paxton gutter'.<sup>13</sup>

The internal iron structure that supported the 'ridge and furrow' roofing was in no way remarkable except perhaps for its size - the building was 277 feet long, 123 feet wide and 67 feet high, and with a central span of 70 feet. More important however was that Paxton, a gardener, had shown that he could successfully organise the construction of a very large building using techniques almost

<sup>13</sup> The evolution of Paxton's glazing system is painstakingly described in G.F. Chadwick, The works of Sir Joseph Paxton, 1961, pp.72-98. This should be read in conjunction with the same author's article Paxton and the Great Stove, Architectural History, Vol.4, 1961, pp.77-91.



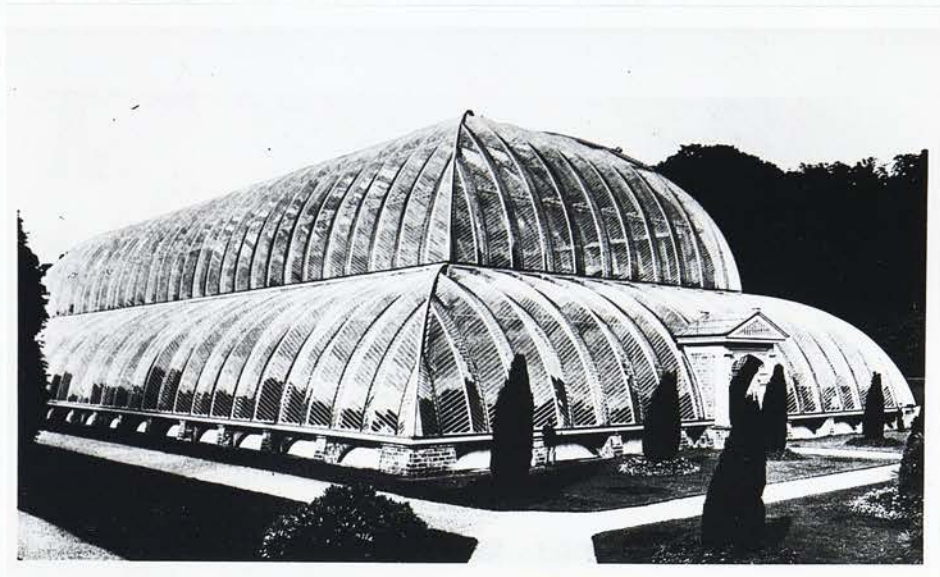


Plate 39. Great Stove, Chatsworth, by Joseph Paxton, 1836-40.

entirely of his own invention, without any substantial help from either architect<sup>14</sup> or engineer. The skill he had shown in the Great Stove was to be of the greatest importance when his proposals for the Great Exhibition were considered by the Commissioners in 1850. The final seal of success was set on the Chatsworth Stove when the Queen and the Prince Consort were conducted through the building in carriages accompanied by the Duke of Devonshire and Paxton in December 1843.

It is not surprising after this visit that in 1844 a large conservatory was planned for the Royal Botanic Gardens at Kew.<sup>15</sup> Decimus Burton was appointed architect, but Richard Turner<sup>15</sup>, the Dublin Ironmaster, would seem to have had a very substantial influence on the design of the building.

The Kew conservatory (See Plate 40) reverted to the characteristic smooth profile of W. & D. Bailey's glasshouses, using iron glazing bars, but the more complex plan gives the building a splendid 'bubble-like' appearance. It is slightly longer than Chatsworth (362 feet) but less lofty and the main span is only 56 feet.

The internal construction is most ingeniously contrived. The framework is composed of 9 inch wrought iron ribs, 42 feet long, at 12 feet 6 inch centres. These ribs were made in about 12 foot lengths

<sup>14</sup> Decimus Burton was consulted, but his contribution seems to have been minimal. See G.F. Chadwick, Paxton etc., pp. 79-82 and G.F. Chadwick, The Works etc., pp. 78-94.

<sup>15</sup> Turner was concerned with the construction of several curvilinear iron conservatories during the 1840's and 1850's. Examples are:- Palm House, Belfast c.1840 See E. McCracken The Palm House and Botanic Gardens, Belfast, 1971, p. 36. Regent's Park, 1846 (also in conjunction with Decimus Burton) See Builder, June 20th 1846, p. 290. Glasnevin, Dublin, 1850, See E. McCracken, op. cit., p. 37. Conservatory and Fruit Houses, Killikee, c.1850, See C.M'Intosh op. cit. p. 376 and Plate 20.

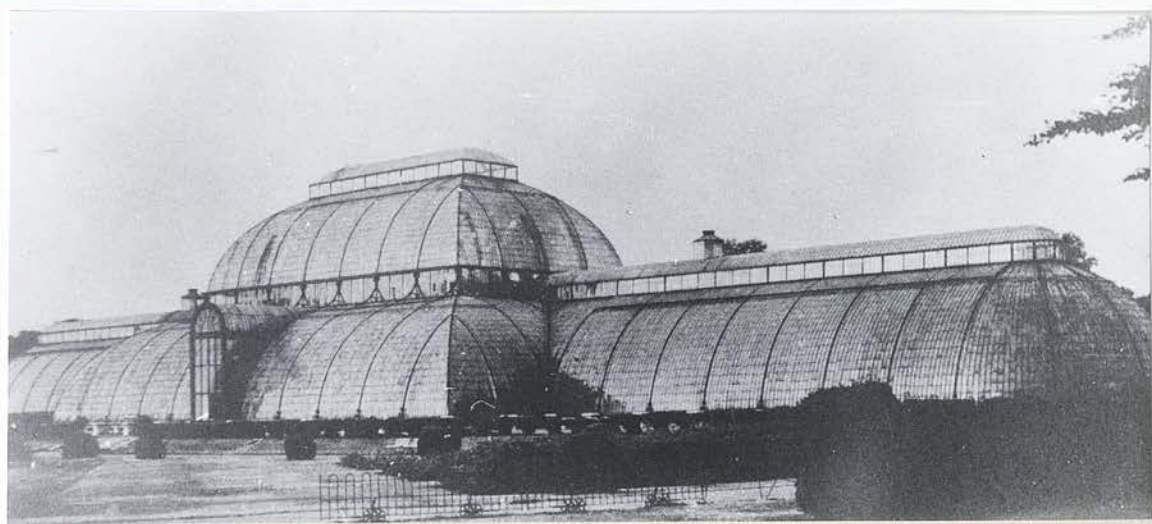


Plate 40. Palm Stove, Royal Botanic Gardens, Kew, by Richard Turner and Decimus Burton, 1844-7.

and then welded<sup>16</sup> together and "bent upon a template to the necessary curve."<sup>17</sup>

The top part of these lower ribs is supported by cast iron columns which in the 'transept' serve to support, in turn, similar ribs in the upper portion of the building. (See Plates 41 & 42). The same rib section is used to link the columns in the other direction. The curved ribs "are braced together, and strutted by wrought iron tie rods passing through cast iron tubes which act as purlins. These purlins . . . . . are formed of a small  $1\frac{1}{4}$  inch round bar welded in long lengths; and, passing through the ribs, they form a continuous tension rod all round the house at each purlin (which are 9 or 10 feet apart) with means of straining them as tight as possible. This tension-bar is enclosed within a tubular bar of cast<sup>18</sup> iron, exactly fitted between the ribs, acting as distance pieces in opposition to the strain of the tensions bars. This knits the entire structure together".<sup>19</sup> (See Plate 43).

This technique is a most remarkable innovation to have occurred at this date. A more conventional solution would have been to increase the size and rigidity of joints at the column heads, as a means of counteracting the outward thrust of the arch form.

<sup>16</sup> This appears to be the earliest recorded instance of the welding of an iron structure.

<sup>17</sup> The Builder, January 19th, 1848, p. 30.

<sup>18</sup> The original text gives "wrought" which must be an error.

<sup>19</sup> The Builder, January 19th 1848, p. 30 and see also Charles M'Intosh, op.cit., pp. 119-23.

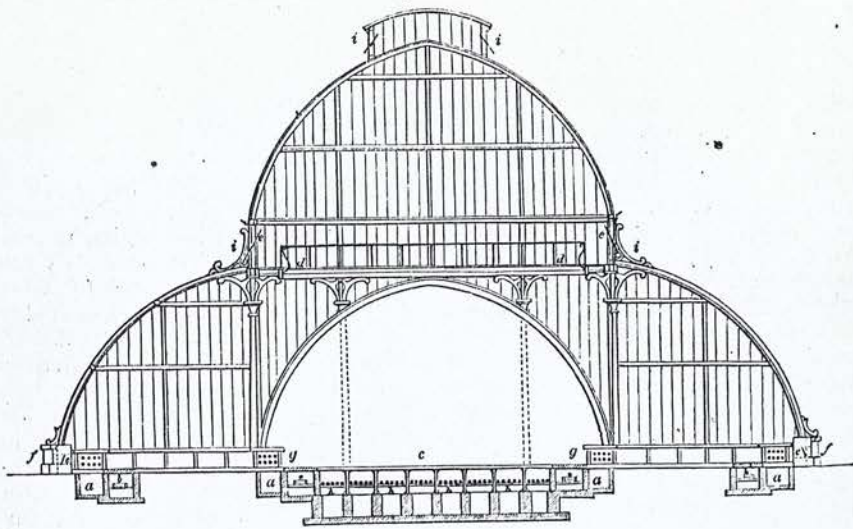


Plate 41. Palm Stove, Kew. Cross section.

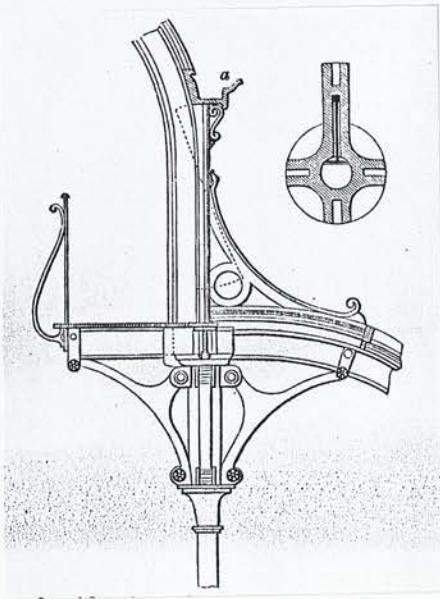


Plate 42. Palm Stove, Kew. Details of Ironwork.



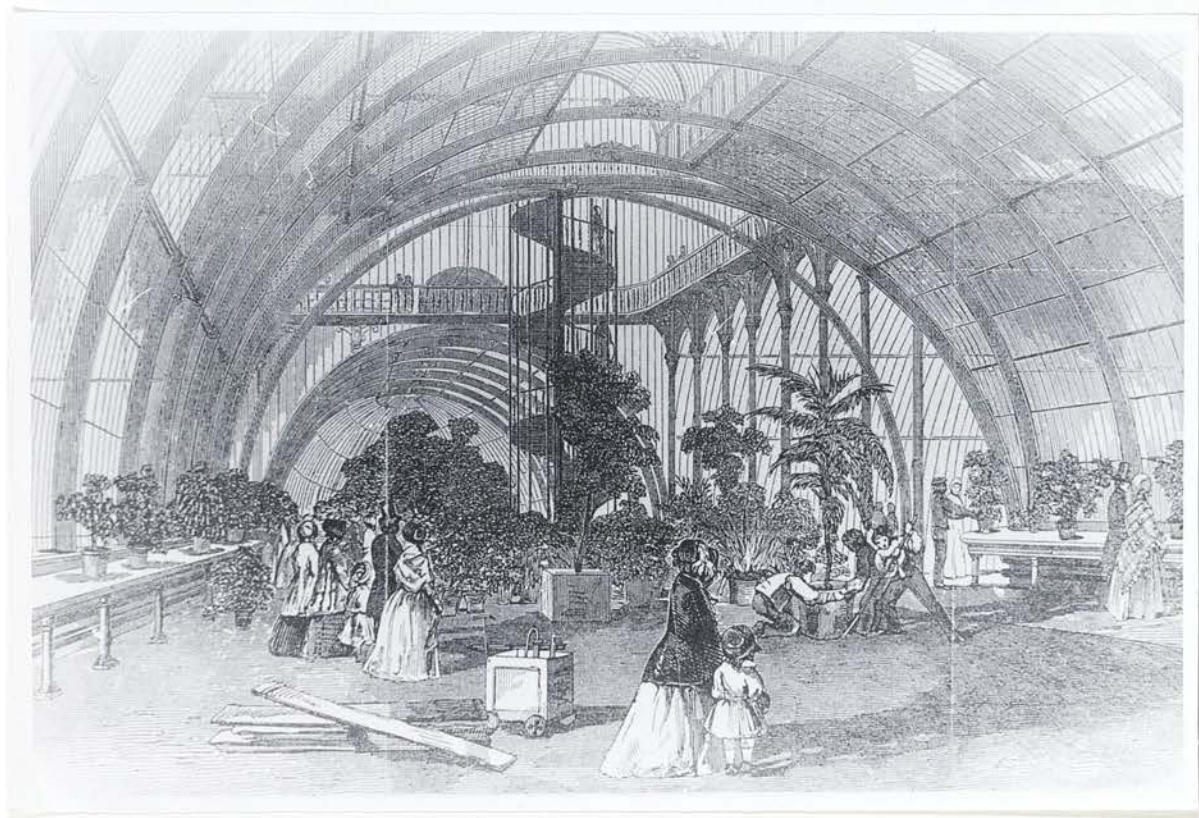


Plate 43. Palm Stove, Kew. Interior view.

It is also characteristic of this building that the tube should also serve as a purlin - a dual function for one element in the structure. A dual functioning of elements also appears in the use of columns to take rainwater away, but here the water is collected in tanks under a perforated floor to maintain the necessary humidity. (g on Plate 41).

Much of the glass used had a curved profile, which added to the cost. In addition, the glass was given a green tint, by means of copper oxide, in order to reduce burning. All of this would have made the building excessively expensive had not this been the first major conservatory to be built after the repeal of the glass tax.

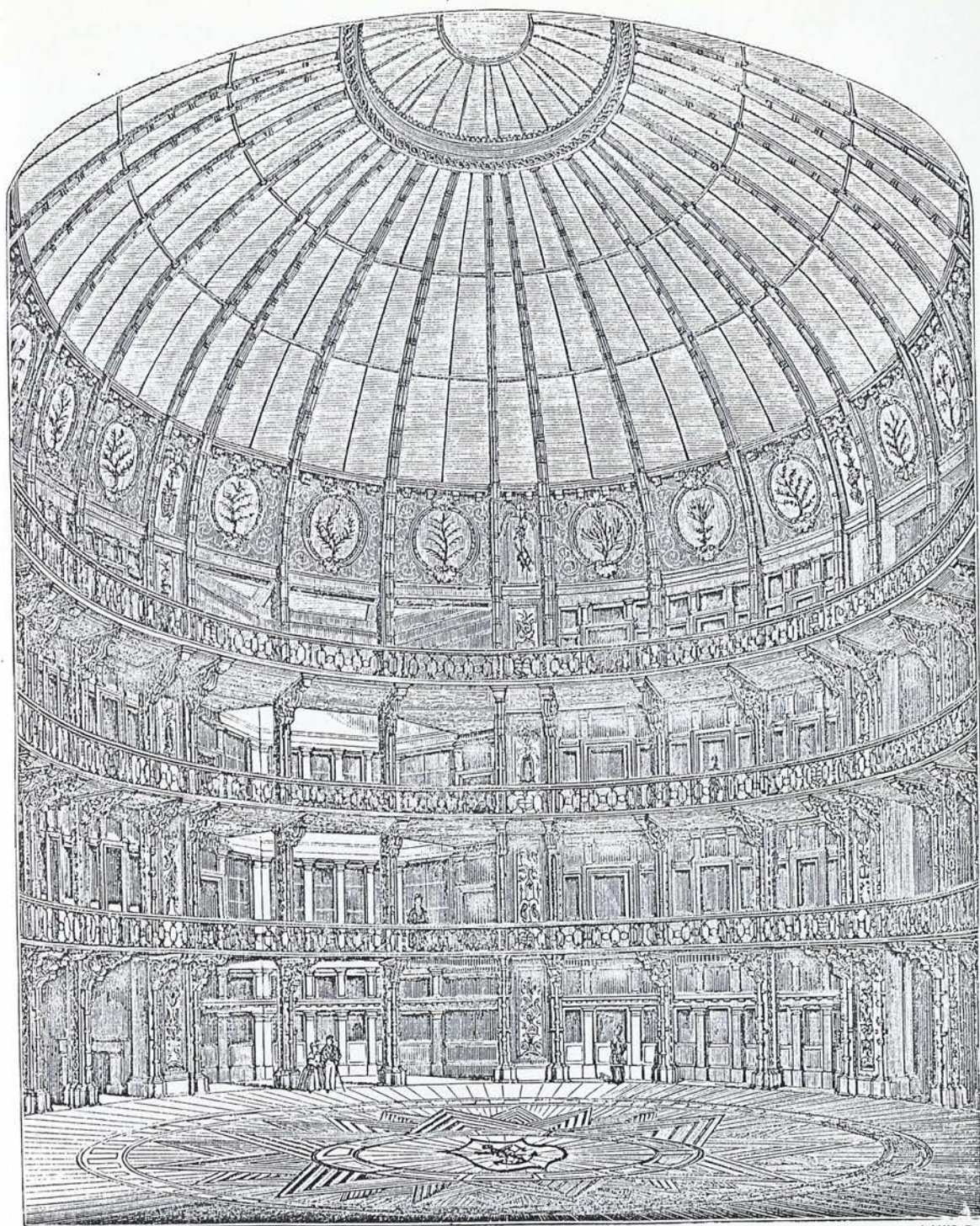
The ironwork details are particularly well designed. Iron scrolls and brackets are detailed in a very restrained manner, and are placed at the right points of the building to alleviate harsh junctions and to give a more intimate scale. The mouldings and decoration were simply chosen to embellish the structure when the eye demanded it.

No such claim could be made for the court of J. B. Bunning's Coal Exchange of 1846-9. (See Plate 44). The internal galleries and domes are entirely of iron and profusely embellished with symbols of the coal trade. The principal motif used in the decoration of the iron work is a rope pattern.

Although it was probably chosen because of its allusion to rope used in mining, this motif is common on 16th and 17th century cast iron firebacks,<sup>20</sup> where it was formed by pressing tarred ropes

<sup>20</sup> Raymond Lister, Decorative Cast Ironwork in Great Britain, 1969, p. 82 and Plate 1b. Illustrations of these firebacks can also be seen in J. Gloag and D. Bridgewater, A History of Cast Iron in Architecture, 1948, Figs. 13-16, and Fig. 22.





LAING 5c

Plate 44. Coal Exchange, London, by J. B. Bunning, 1846-9.  
The court.



into the moulding sand. Ropework patterns appear on the ground and first floor stanchions and brackets, (See Plate 45) and on the balcony soffites where the ropework design encircles either coal balances, (See Plate 46) or anchors. Even the balconies are designed with a repetitive motif of entwined ropes. All this may seem to our eyes to verge on the vulgar, but it is entirely consistent in a Victorian commercial building to find an expression of boundless confidence. It is most interesting to find that a contemporary critic considered that the building's main virtue was its fitness to its purpose: "We have here a structure which manifests at once that the architect very properly made its purpose and destination the first and ruling thought. He obviously did not begin his elevation by attempting to metamorphose a Doric temple, or a mediaeval cathedral, or an Italian villa, into a something essentially different; but rather allowed the building to take its own form and character from its own conditions and purpose. The result has been that this erection is marked by a welcome originality of its own, not only in its structural forms, but in the details of its arrangements; and in the materials used Mr. Bunning has successfully employed iron and glass abundantly, usefully, and ornamentally."<sup>21</sup>

The importance of Bunning's building, apart from the decoration, and its functional aptness, was that it established a prototype that was followed in almost every coal, wool or corn exchange that

<sup>21</sup> Journal of Design and Manufactures, Vol. II, 1849/50, p. 148.

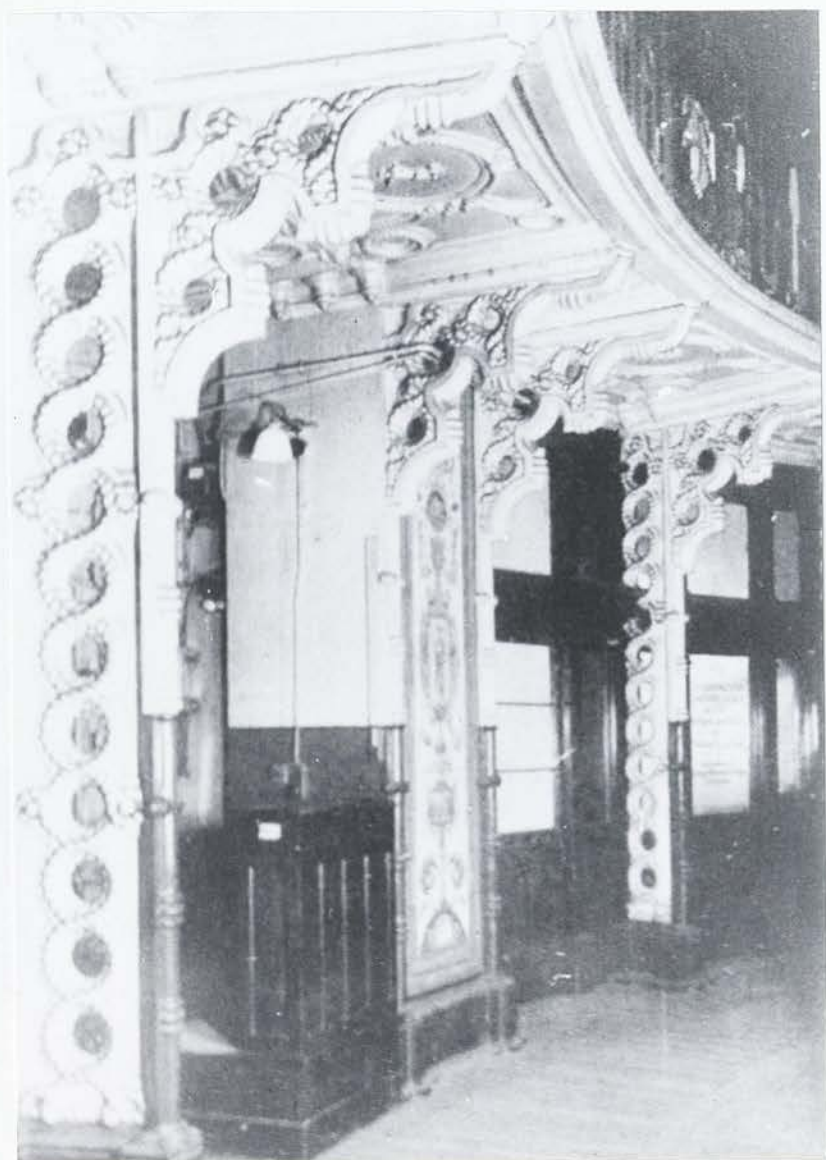


Plate 45. Coal Exchange, London. Ground floor stanchions.



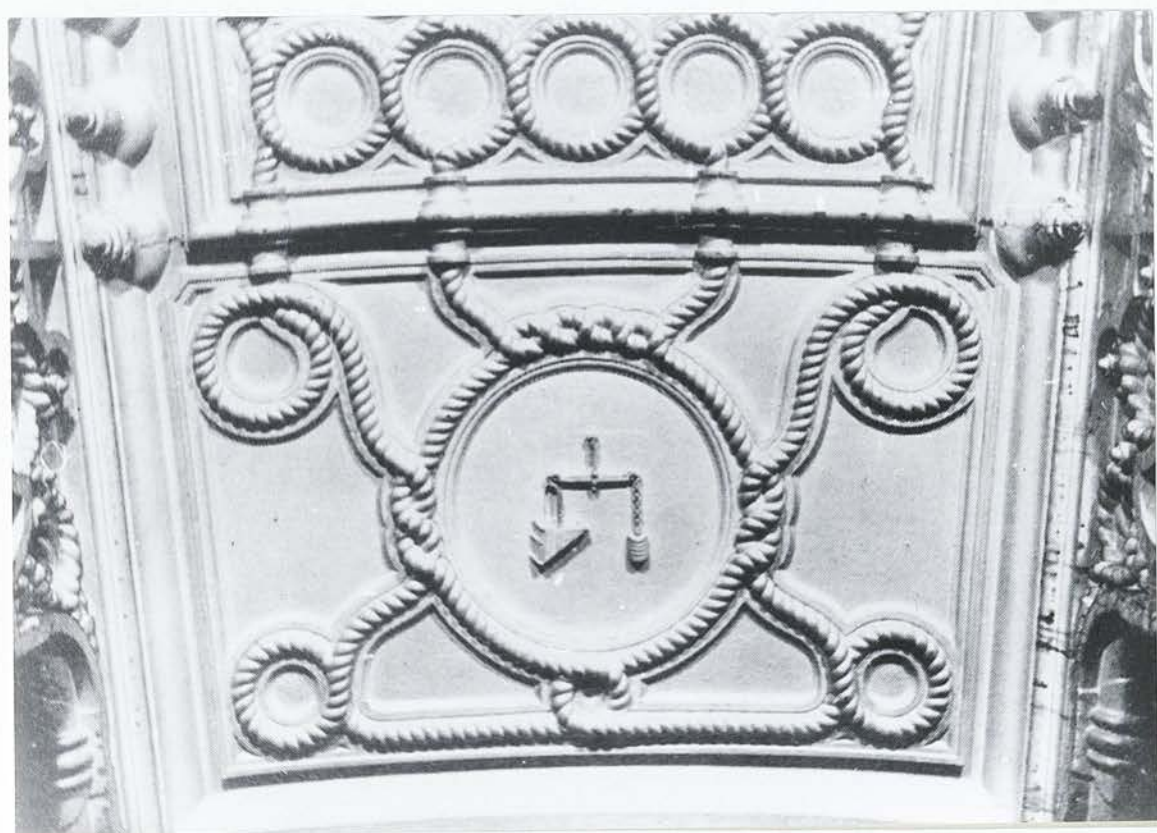


Plate 46. Coal Exchange, London. Balcony soffite.

was built in any industrial city in Britain in Victorian times.<sup>22</sup>

By the time that the Coal Exchange was completed in 1849, plans were already under way for the Great Exhibition of Industry in 1851. No event more aptly expresses the supreme confidence that Victorian Britain had in its industry and commerce. (See Plate 47). The great 'palace of glass' that housed the Exhibition can be seen as a symbol of this confidence. A contemporary critic wrote: "The building for the Exhibition is the greatest evidence that the Exhibition affords of the industrial resources of this country. It shows, perhaps, more than any single building that has ever been erected, the capabilities of labour, the resources of capital, and the energetic direction and working of the appliances of mechanical skill."<sup>23</sup>

The amount written about the Great Exhibition building is formidable. No other building was given such extensive coverage, during and immediately after its construction.<sup>24</sup>

<sup>22</sup> In addition, the metal ribbed dome, which allowed for a greater area of glazing and thus higher daylighting levels than a masonry dome, began to be used for other buildings. Sydney Smirke's Reading Room, added to the British Museum in 1854-7, is a typical example.

<sup>23</sup> The Great Exhibition and its Influence upon Architecture, Architectural Quarterly Review, Vol. I, No. 1, June 1851, p. 25.

<sup>24</sup> The best technical accounts of the buildings are: Matthew Digby Wyatt, On the Construction of the Building for the Exhibition of the Works of Industry of all Nations in 1851, Proceedings of the Institution of Civil Engineers, Vol. X, 1850-1, pp. 127-91. M. D. Wyatt, The Construction of the Building, in the Official Descriptive and Illustrated Catalogue of the Great Exhibition, 1851, pp. 49-81. On the Great Exhibition of the Works of Industry of All Nations, 1851, in Cyclopaedia of Useful Arts, edited by Charles Tomlinson, 1854, Vol. I. In addition the Illustrated London News gave extensive coverage during 1850 and 1851 of the construction of the building. The best drawings are contained in Charles Downes, The Building Erected in Hyde Park for the Great Exhibition of the Works of Industry of All Nations, 1851, 1852.\*





Plate 47. Great Exhibition, 1851. Cover of the Official Descriptive and Illustrated Catalogue of the Great Exhibition, 1851.

The derivation of the design from Paxton's work at Chatsworth is well known,<sup>25</sup> - particularly the Exhibition building's immediate predecessor; the 'Victoria Regia' House completed in 1850.<sup>26</sup>

After a competition for the building, held in the spring of 1850, had yielded no satisfactory winner, the Commissioners of the Exhibition submitted their own design. After much discussion they decided not to go ahead with this design on grounds of cost.<sup>27</sup> Paxton's proposal first appeared in the Illustrated London News on the 6th July. After rather rapid preparation, an estimate of £79,800 by Messrs. Fox and Henderson was submitted and accepted by the Commissioners on July 26th.

The date for the official opening of the Exhibition had been fixed for the 1st May the following year, which left just over nine months for the building to be fully designed, detailed and constructed. The credit for the amazingly short time taken to prepare the detailed design must be given to Charles Fox. Fox described<sup>28</sup> how he had worked eighteen hours a day for seven weeks on the detail drawings and as soon as a drawing was finished he passed it on to Henderson who immediately "prepared the iron work and other materials required in the construction of the building."<sup>29</sup> At the same time tests were

<sup>25</sup> G. F. Chadwick, op.cit., Chapter 4.

<sup>26</sup> Ibid., p. 89. An excellent contemporary description of this building is given in The Cottage Gardener and Country Gentleman's Companion, Vol. 19, 1858, p. 83.

<sup>27</sup> The lowest tender submitted for this design, which was largely of brick construction, was £120,000.

<sup>28</sup> Speech at Derby, 21st June 1851. See Cyclopaedia of Useful Arts, pp. xxii-iv.

<sup>29</sup> Ibid., p. xxii.



made at Fox and Henderson's works at Birmingham on sample portions of the structure and after these proved satisfactory casting went ahead. Because of the enormous number of components, some of the work was given to neighbouring foundries to cast.<sup>30</sup>

Components started to be delivered to the Hyde Park site at the beginning of September and by the 26th of the month the first column was fixed in place. From this date Fox took the management of the construction under his charge and spent all his time on the site.

The Great Exhibition building has often been incorrectly described as being solely composed of iron and glass. The main structure was certainly of iron, with the exception of the main transept ribs<sup>31</sup> which were fabricated by laminating timber. The roof cladding, however, was entirely of timber and glass using Paxton's 'ridge and furrow' system.

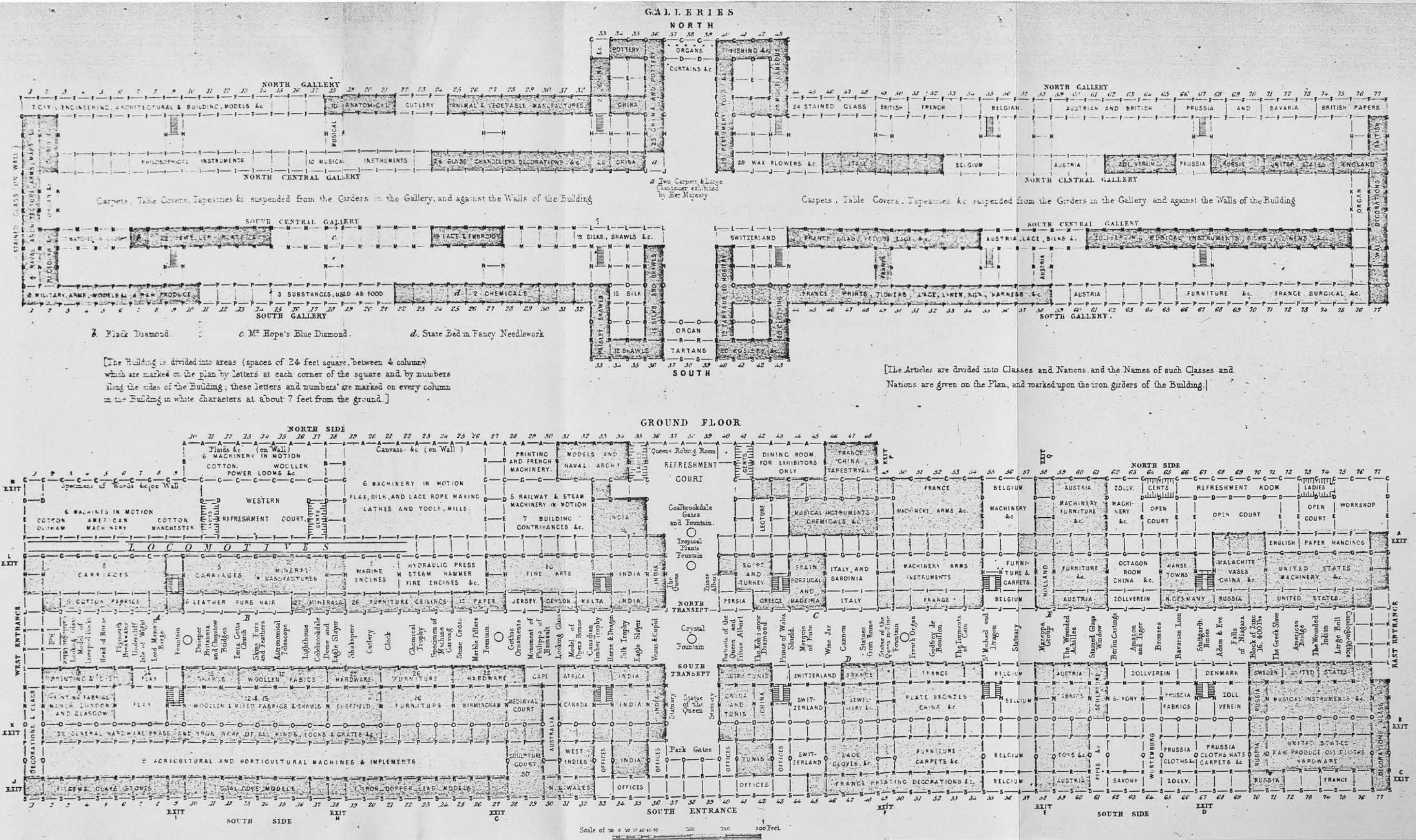
The building was planned using a 24 feet square bay. (See Plate 48). It was seventy seven bays long (1848 feet) and seventeen bays wide (408 feet) with a two bay projection on the north side. Each bay was divided into three on the external wall. (See Plate 49).

In order to describe the structure of this vast building, it is wise to follow Wyatt's example and look at a typical 24 feet bay. The

<sup>30</sup> Messrs. A. and B. Cochrane, Dudley, and Messrs. Jobson of Holly Hall, near Dudley.

<sup>31</sup> The arched transept did not appear on Paxton's original design. It was added as a result of suggestions made by the Commissioners in July 1850. See G.F. Chadwick, op.cit., p.112.

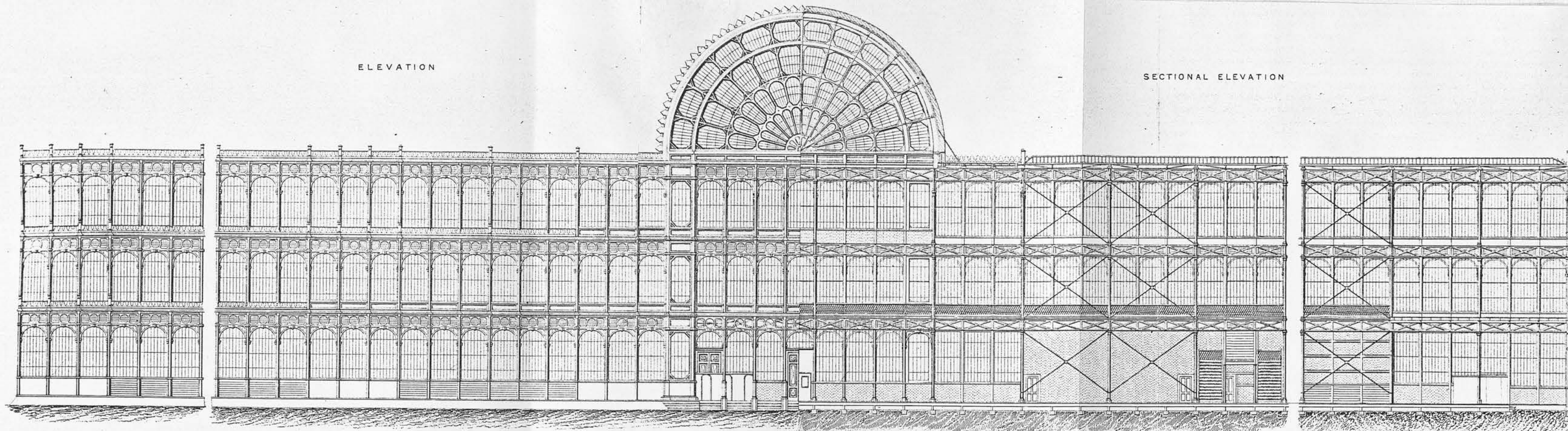






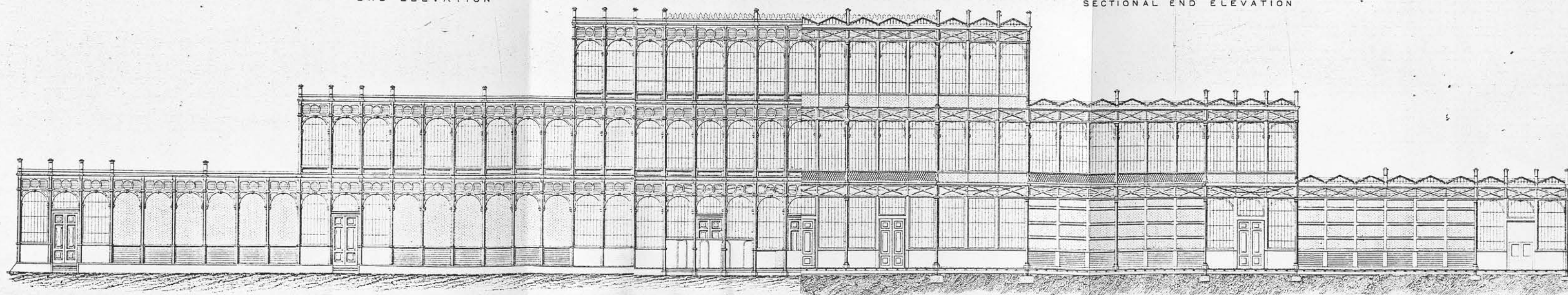
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column<sup>32</sup> at the corner of the bay had a base plate (See Plate 50) which rested on a concrete footing. The jointing surfaces on the column and base plate having been 'planed' perfectly true, a piece of canvas cut to the exact shape of the bearing surface and soaked in white lead was laid between the surfaces before the joint was tightened. This ensured that the joint was completely secure and water-tight.

At the top of the column a 'connecting piece' of the same cross section as the column was bolted on in a similar manner. (See Plate 51). The 'connecting piece' enabled the trusses to be joined to the column in four directions and it varied in length according to the depth of the truss. The joint between the truss and column was effected by the hooked projections at top and bottom and the joint was secured by a mortice and tenon device at the bottom (A on Plate 51) and by an iron dowel driven into a groove at the top.

The typical truss of 3 feet depth for the 24 feet span was made of cast iron, (See Plate 52) but over the larger spans the trusses were fabricated from wrought iron sections. The basic design remained the same - crossed diagonal members with vertical struts at 8 feet centres.

The typical arrangement of roof glazing is shown in Plate 53. 'Paxton gutters' with an iron rod trussed below (See Plate 54) spanned the 24 feet between trusses, and these in turn supported the 'ridge and

<sup>32</sup> These 8 inch diameter columns had a standard external profile but the thickness of the metal varied from  $\frac{3}{8}$ th of an inch to  $1\frac{1}{8}$  inches, depending on the position of the column in the structure.

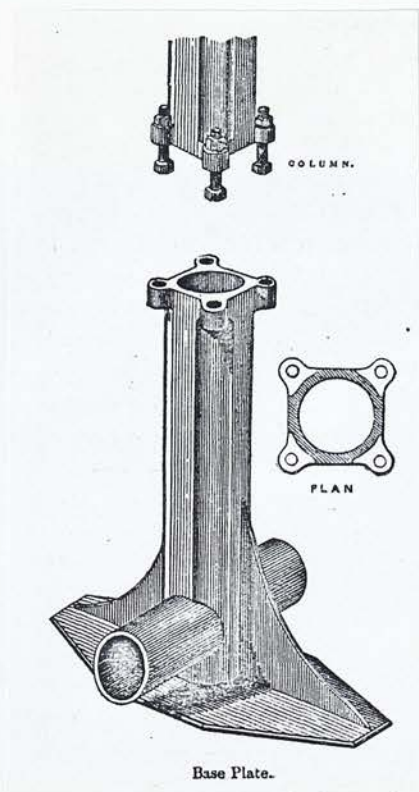


Plate 50. Great Exhibition Building. Detail of base plate to column.

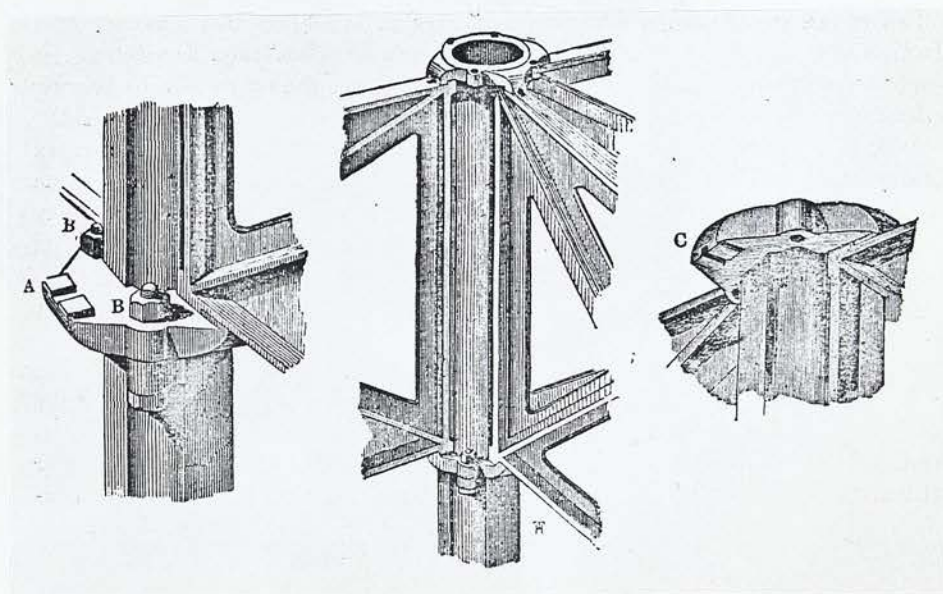


Plate 51. Great Exhibition Building. Junction of typical column and truss.



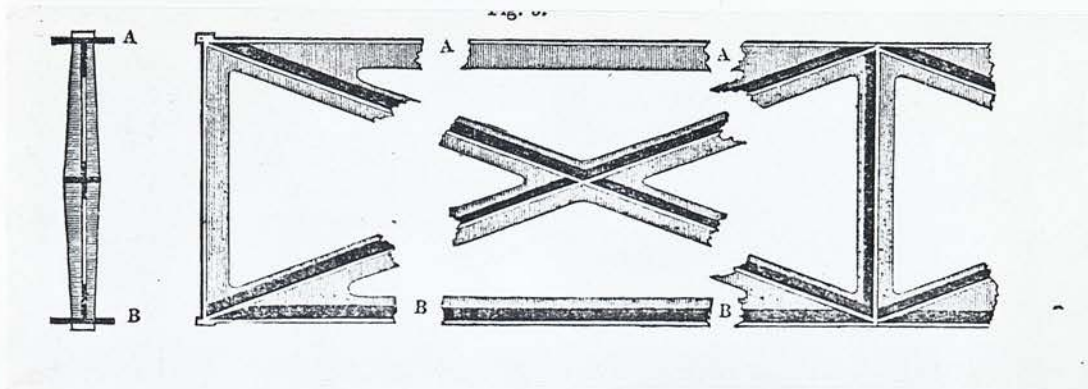


Plate 52. Great Exhibition Building. Typical truss of 24 feet span.

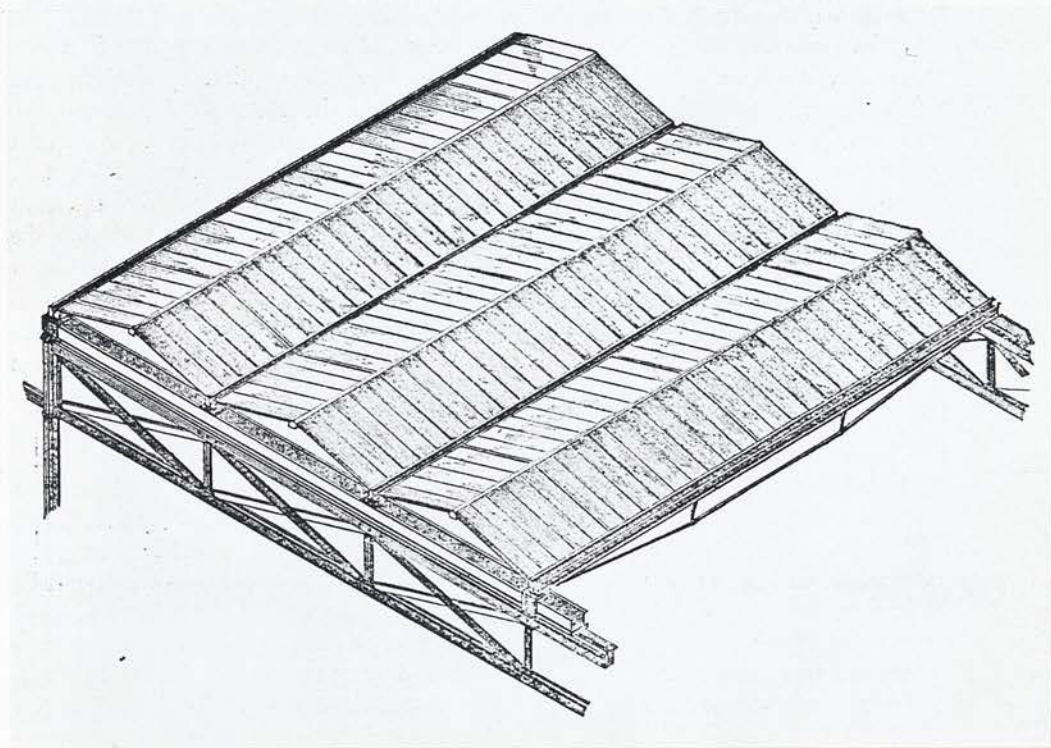


Plate 53. Great Exhibition Building. Roof construction of typical 24 feet square bay.



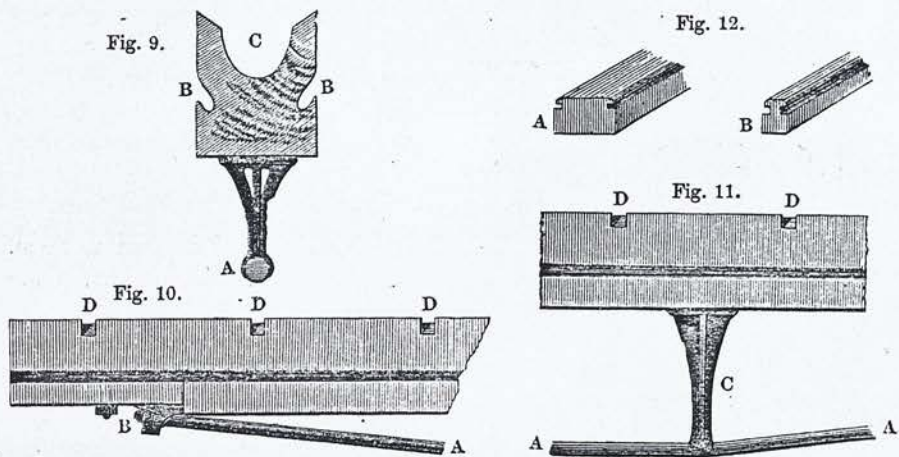


Plate 54. Great Exhibition Building. 'Paxton gutter.'

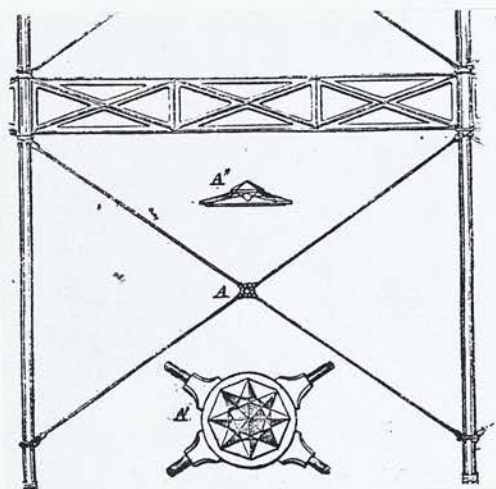


Plate 55. Great Exhibition Building. Typical diagonal bracing.

furrow' glazing with timber rafters of  $2\frac{1}{2}$  inches by 1 inch section. (A on Plate 54). Rainwater was conducted along the 'Paxton gutter' (C) into a timber box gutter along the line of the truss and then into the column. (See Plate 53). The box gutter also collected the condensation that ran down the grooves in the side of the 'Paxton gutter'. (B on Plate 54).

This characteristic that components were endowed with more than one purpose was a major factor in the economy of the building.

The absence of internal walls in the building necessitated some form of bracing and this was introduced by diagonal rods of wrought iron connected at the centre by a cast iron ring. (See Plate 55). The ring was afterwards fitted with an "ornamental cast iron face."<sup>33</sup>

The extraordinary speed at which the building was erected was partly due to the mass production of iron components,<sup>34</sup> but the application of machines to many aspects of the construction also had a major effect. A spindle moulder was used to produce the 20 miles of 'Paxton gutter'. (See Plate 56). A similar machine mass-produced the 205 miles of sash bar required. (See Plate 57). Even the painting of the sash bar was partially mechanised. (See Plate 58). In addition Paxton contrived a glazing wagon which ran along the grooves in the gutters. (See Plate 59).

Of course the intensive use of labour was also important in the rapid completion of the building. After the beginning of December 1850 no less than two thousand men were continuously employed on

<sup>33</sup> Cyclopaedia of the Useful Arts, p.xxviii.

<sup>34</sup> During October and November 1850 approximately 200 columns were supplied and fixed each week. There were 3,300 columns in the completed building.

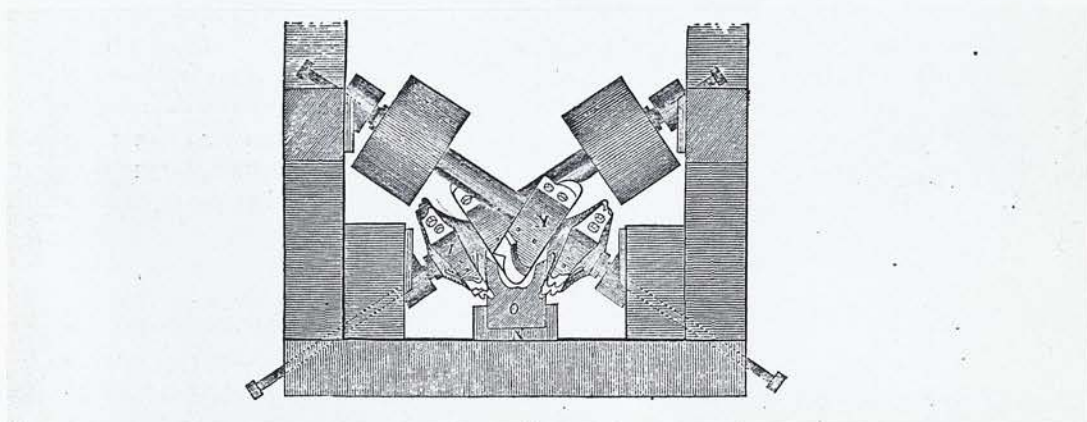
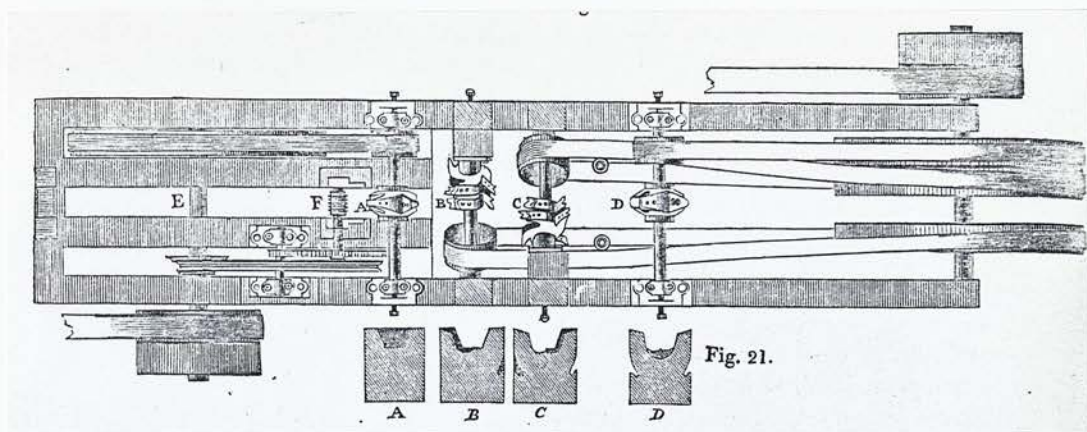


Plate 56. Great Exhibition Building. Spindle moulding machine for the 'Paxton' gutter.

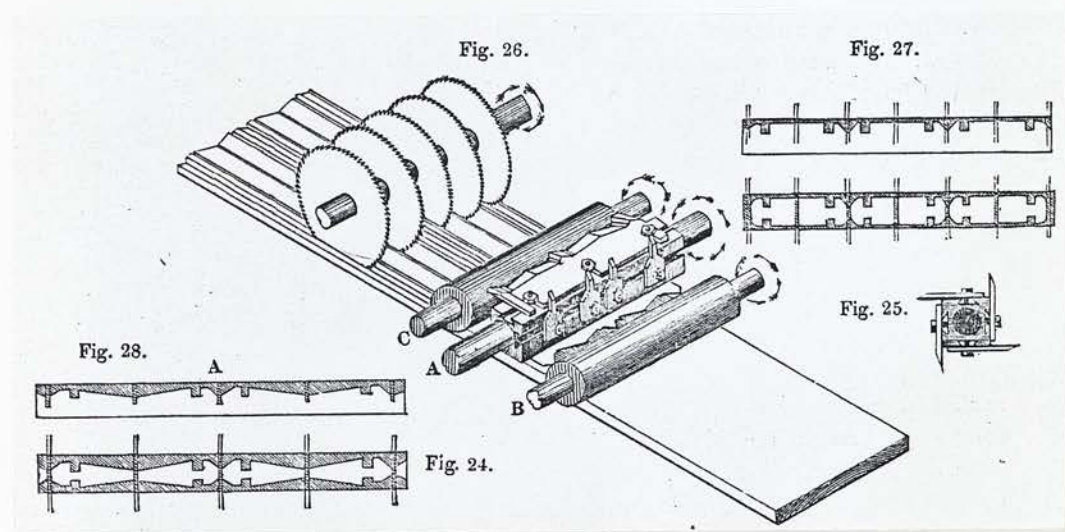


Plate 57. Great Exhibition Building. Sash bar machine.



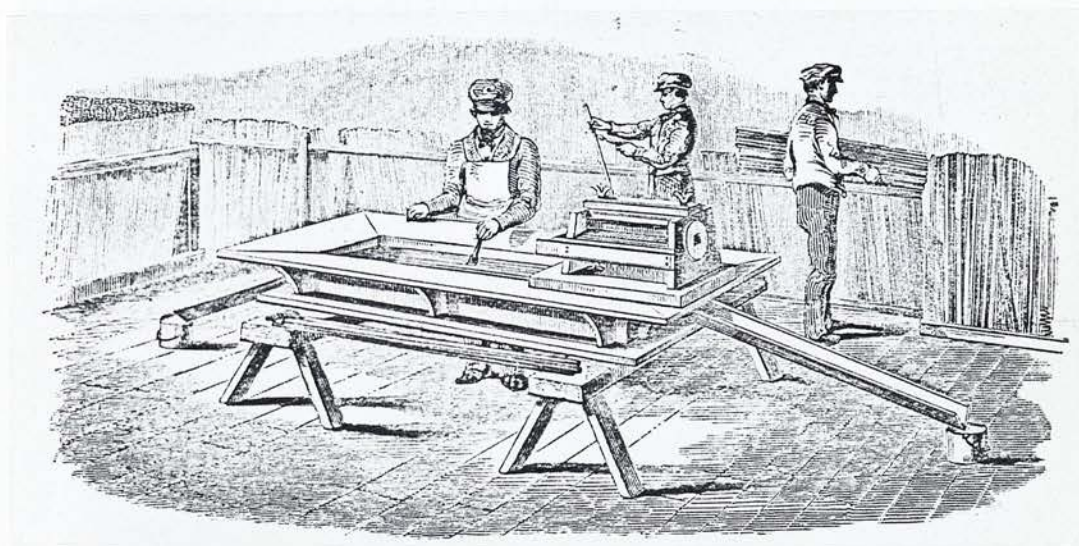


Plate 58. Great Exhibition Building. Machine for painting the sash bars.

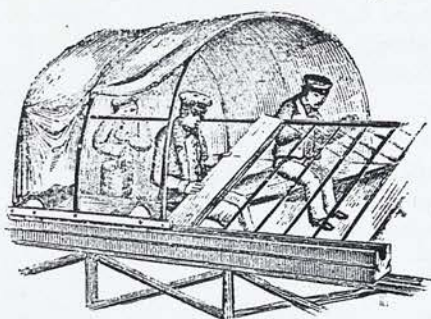


Plate 59. Great Exhibition Building. Glazing wagon.



the site until the completion of the building at the end of April 1851.

No attempt was made to ornament any part of the structure but when the final painting was considered Owen Jones prepared a quite remarkable scheme.<sup>35</sup> He used the three primary colours in juxtaposition, with thin white lines between them. Each element in the structure was painted the same colour so that "in perspective each column . . . . allied itself in colour with its fellow column, each vertical face of girder with the vertical faces of its fellow girders, and each soffite . . . with its fellow soffites".<sup>36</sup>

Naturally enough an ingenious colour scheme was not enough to silence the critics who felt that the building had no place in the domain of Architecture.

This view is succinctly expressed in an article on the Great Exhibition building and its influence on Architecture,<sup>37</sup> published in the year of the Exhibition. "But let it be distinctly understood by all who are carried away by its vastness, or by the splendour, and general effects of its contents, that the building has no claim whatever to be considered as a work of ART, and is no evidence of what the Art of Architecture could accomplish whether now or at any other time. Mere length or height, or general size, or number of parts,

<sup>35</sup> The scheme proposed was discussed in a paper read at the Institute of British Architects in December 1850 and was subsequently printed in Owen Jones, Lectures on Architecture and the Decorative Arts, 1863 (Printed for private circulation).

<sup>36</sup> M.D. Wyatt, Construction of the Building etc., p. 67.

<sup>37</sup> The Great Exhibition etc., Architectural Quarterly Review, Vol. 1, No. 1, June 1851.

may produce a certain effect, but may exist without contributing one quality to the effect of Beauty in Architecture".<sup>38</sup>

The Ecclesiologist predictably supported the view that the building could never be considered as Architecture, but it was even more enthusiastic about the internal spatial effects. "And we freely admit, that we are lost in admiration at the unprecedented internal effects of such a structure . . . . an effect of space, and indeed an actual space hitherto unattained; a perspective so extended, that the atmospheric effect of the extreme distance is quite novel and peculiar; a general lightness and fairy-like brilliancy never before dreamt of."<sup>39</sup> (See Plate 60).

There were those critics who felt that the building had somehow initiated "an entirely novel order of Architecture."<sup>40</sup> Fergusson believed that the building had inaugurated a "new style of Architecture"<sup>41</sup> - that recurrent and largely unfulfilled hope of the 19th century.

Even Fergusson felt the need to qualify this claim. He felt that the building, even after its re-erection at Sydenham<sup>42</sup>, lacked solidity and the appearance of permanence that would make it "really

<sup>38</sup> Ibid., pp. 25-6.

<sup>39</sup> The Design of the Crystal Palace, the Ecclesiologist, Vol. XLI, 1851, p. 269.

<sup>40</sup> From a speech given at the opening of the Exhibition by Mr. Laing. Quoted in J. Ruskin, The Opening of the Crystal Palace, in On the Old Road, Vol. I, p. 351.

<sup>41</sup> James Fergusson, History of the Modern Styles of Architecture, 1862, p. 482.

<sup>42</sup> G. F. Chadwick, op. cit., Chapter 6 and Appendix III.



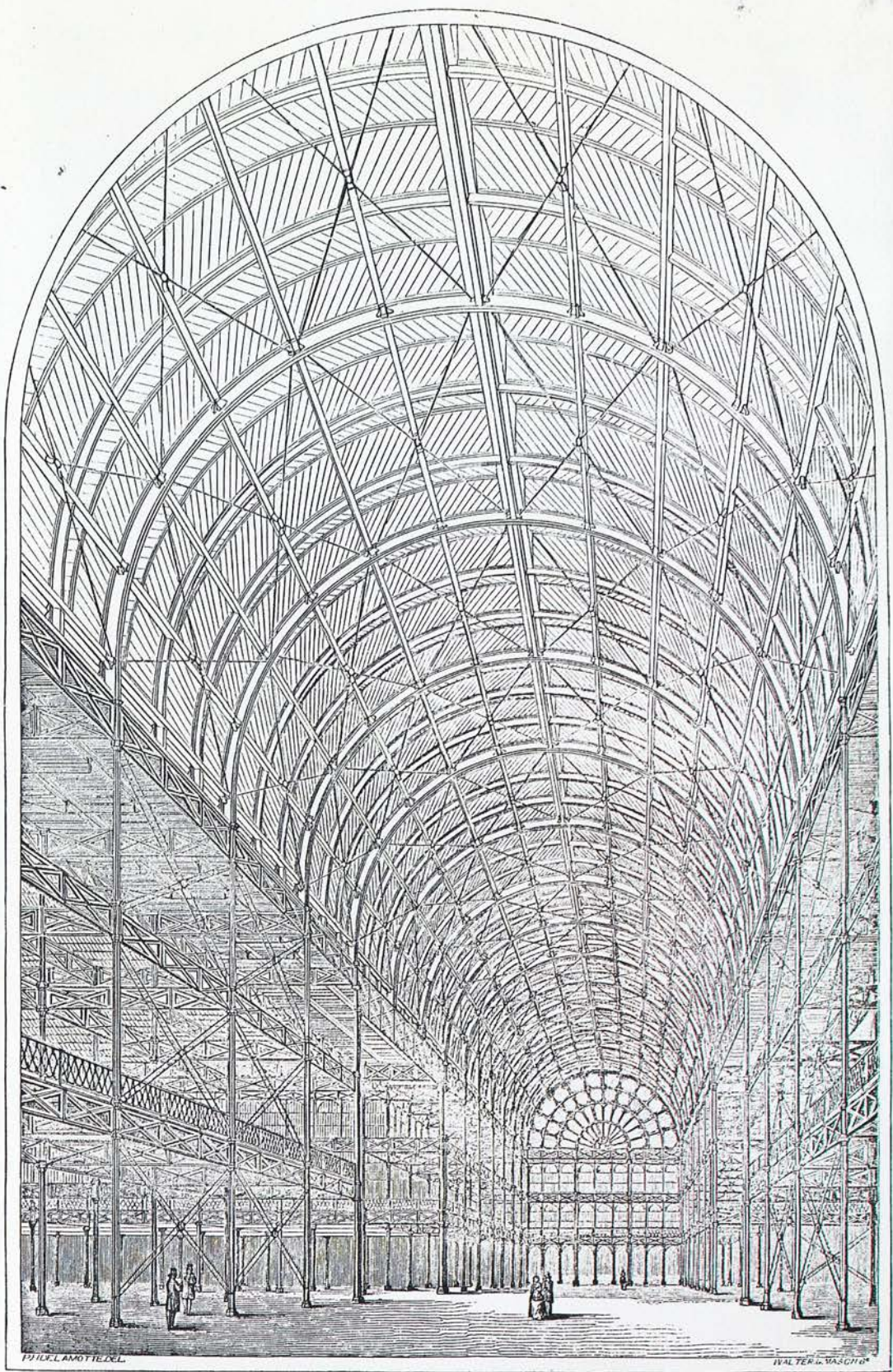


Plate 60. Great Exhibition Building. Interior view from south entrance.



architectural in the strict sense of the word."<sup>43</sup> He also felt that it lacked a sufficient amount of decoration to take it out of the category of first-class engineering.

The problem of the correct decorative treatment for ironwork was one which greatly exercised Ruskin in his close guidance of the design of Deane and Woodward's Oxford Museum which began to be built in 1855. Although the building is more justly known for its attempt at the application of Ruskinian principles in the stone carvings, the internal court with its glazed roof is the first important example of an attempted application of the principles to iron structures.

The principles applied here are quite clearly laid out in Ruskin's *Seven Lamps of Architecture*. In the Lamp of Truth he categorically rejects any form of machine made ornament<sup>44</sup> on the grounds that the quality of ornament is greatly effected by the "sense of human labour and care spent upon it."<sup>45</sup> Predictably he chooses the precedent of mediaeval ironwork as a pattern. "The common ironwork of the middle ages was as simple as it was effective, composed of leafage cut flat out of sheet iron, and twisted at the workmans will."<sup>46</sup> It was a central part of Ruskin's doctrine that the forms of decoration should be derived from nature.

<sup>43</sup> James Fergusson, *op.cit.*, p. 483

<sup>44</sup> J. Ruskin, *The Seven Lamps of Architecture*, 1849, p. 32.

<sup>45</sup> *Ibid.*, p. 48.

<sup>46</sup> *Ibid.*, p. 51.



When it came to applying these principles to the ironwork in the Museum, the result was rather unsatisfactory. The columns were made of cast iron after attempts to construct them in wrought iron had resulted in structural failure.<sup>47</sup> The capitals were formed by applying wrought iron in foliage patterns to the cast iron cores. (See Plate 61). Eastlake's judgement on these capitals is most penetrating. "But in the case of the iron capital to which beaten metal is subsequently attached, as at the Oxford Museum, we feel that the ornaments of leaves and flowers, however excellent in themselves, are mere additions having no sort of relation to the constructive feature which they adorn and claiming a raison d'être of scarcely higher pretensions than the plaster enrichments of a brick cornice."<sup>48</sup> The ironwork to each capital was varied in detail to accord with Ruskin's dislike of the repetitive nature of cast iron ornament.

The ribs of the structure in wrought iron were formed into pointed arches. (See Plate 62). They were fabricated from small sections by rivetting which led to numerous ugly rivet heads on the surface of the ribs. This was partly disguised by painting the surfaces with a decorative foliage pattern in buff and maroon. The

<sup>47</sup> H. W. Acland and J. Ruskin, The Oxford Museum, 1859, pp. 30-31.

<sup>48</sup> Charles L. Eastlake, A History of the Gothic Revival, 1872, p. 285.

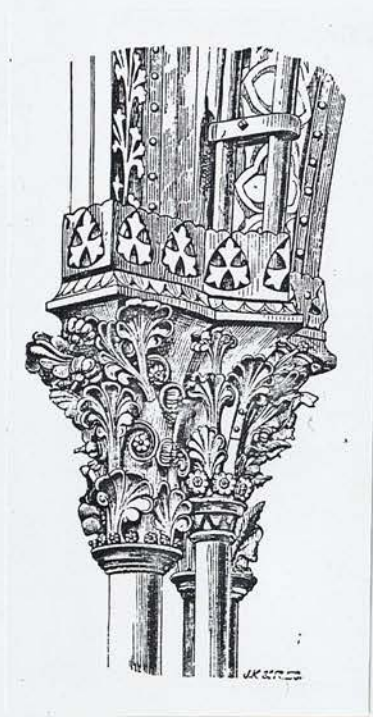


Plate 61. University Museum, Oxford by Sir T. Deane and B. Woodward, 1855-68. Detail of iron capital in quadrangle.

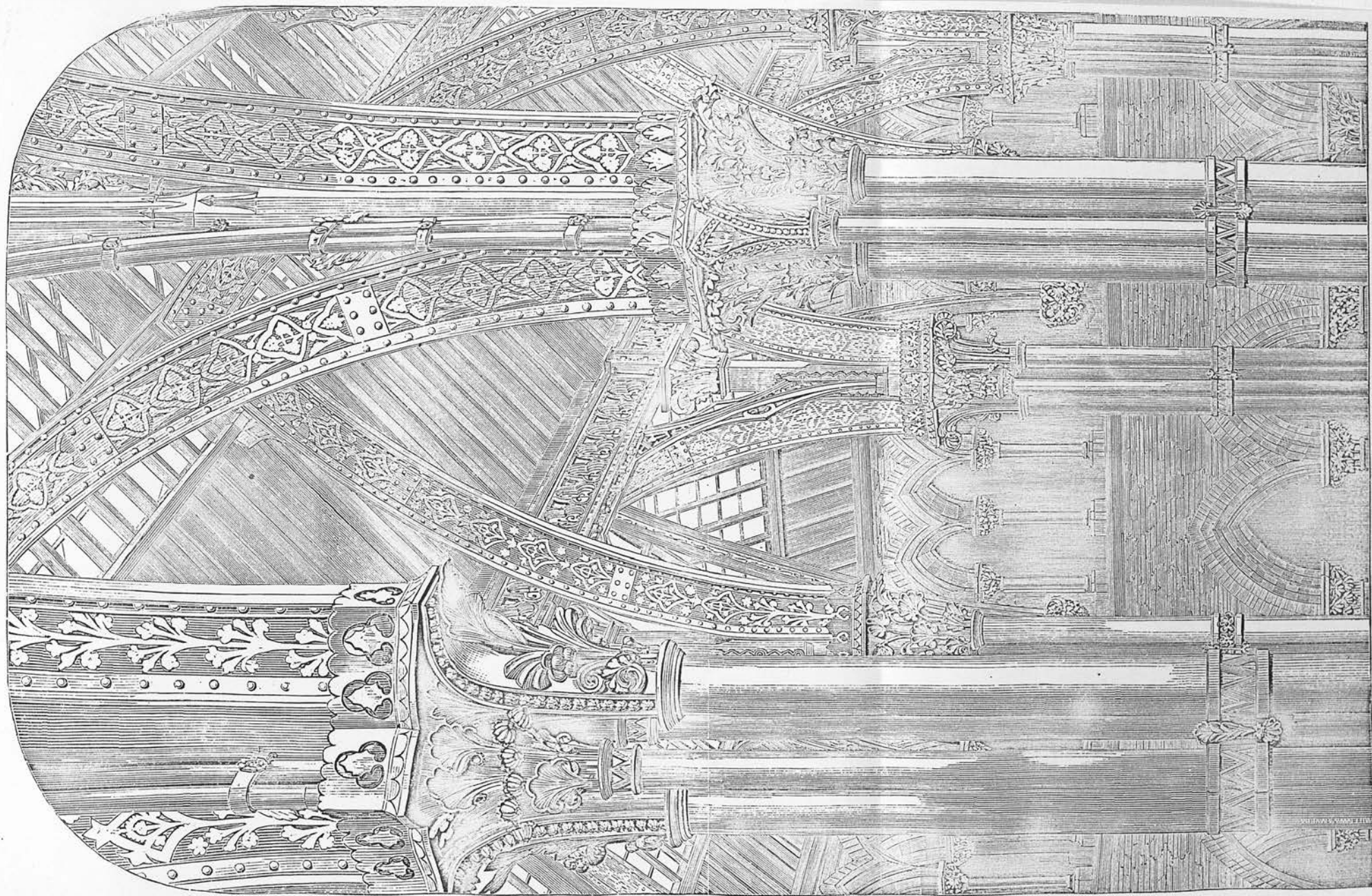


Plate 62. University Museum, Oxford. View of quadrangle.

spandrels were filled with filigree wrought iron designs<sup>49</sup> based on the foliage of various trees.<sup>50</sup> Plate 63 is an example using the foliage and nuts of the horse chestnut as a motif.

In spite of Ruskin's influence over the design he was very critical of the completed building. He felt that the ironwork had somewhat mis-represented the principles which he was "endeavouring to enforce."<sup>51</sup> He nevertheless saw the Oxford Museum as a guide in the right direction and looked forward to "lovelier and juster expressions of the Gothic principle"<sup>52</sup> in the future.

Ruskin's hope was never fulfilled. Even in the domain of church building, neither the efforts of Ruskin nor the Ecclesiologists could really bring iron into the vocabulary of the revived Gothic style.

<sup>49</sup> All the designs for the ironwork were made by Mr. F.A. Skidmore of Coventry. Skidmore like Ruskin felt that the Museum "held out the possibility of uniting artistic iron work with present tubular construction and a prospect of a new feature in the application of iron to Gothic architecture". See H.M. and K.D. Vernon, A History of the Oxford Museum, Oxford 1909, p.69.

<sup>50</sup> The University Museum, Oxford, The Builder, July 7th 1855, p.318.

<sup>51</sup> H.W. Acland and J. Ruskin, op.cit., p.90.

<sup>52</sup> Ibid., p.90.



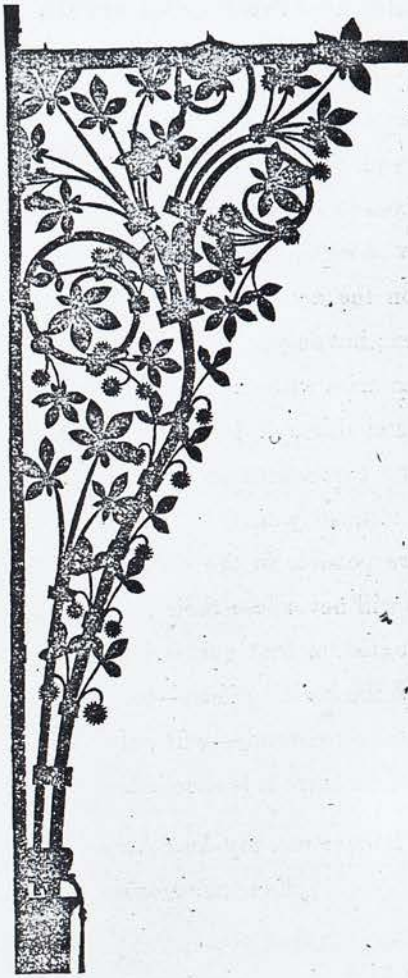


Plate 63. University Museum, Oxford. Wrought iron spandrils.

The use of iron in Victorian church building never became firmly established. After the hopeful start by Richard and Henry and the experiments of the Church Commissioners in 1813, iron was lost and less used except in columns as gallery supports. Even the use of galleries declined as the architects of the Gothic revival turned to more exact precedents both in style and in the arrangements of churches.

Between the time that St. Philip's was completed in 1816 and until the use of temporary iron churches became common in the 1840's, only two solitary examples are to be found of the radical use of iron in churches. The first, and by far the most interesting was

## CHAPTER V

St. John's Church, Bowling, near Bradford.

### Iron churches in the mid-century and the Ecclesiological Society (1840-62).

Bowling Iron Works "for the use of their numerous workmen and the surrounding population." The 'Early English' design was provided by Richard and Samuel Sharp.<sup>1</sup> The construction was a combination of iron and stone with the exception of the timber roof. Iron was used for the pillars and for all the ribs of the vaults and the interferences of the vaults were filled with stone. (See Plate 54). The nave pillars, which were 15 feet 6 inches high, were constructed

<sup>1</sup> Were given 1842. The evidence of Richard Sharp's letter published in the Civil Engineer and Architect's Journal is to be preferred. (December 18th 1830).

<sup>2</sup> Civil Engineer and Architect's Journal, December 18th 1830, p. 41.

<sup>3</sup> Richard Henry Sharp and his younger brother Samuel had an architectural practice in York. See Colvill, p. 336 and Ware, p. 214.

The use of iron in Victorian church building never became firmly established. After the hopeful start by Rickman and Cragg and the experiments of the Church Commissioners in 1818, iron was less and less used except in columns as gallery supports. Even the use of galleries declined as the architects of the Gothic revival turned to more exact precedents both in style and in the arrangements of churches.

Between the time that St. Philip's was completed in 1816 and until the use of temporary iron churches became common in the 1850's, only two solitary examples are to be found of the radical use of iron in churches. The first, and by far the most interesting was St. John's Church, Bowling, near Bradford.

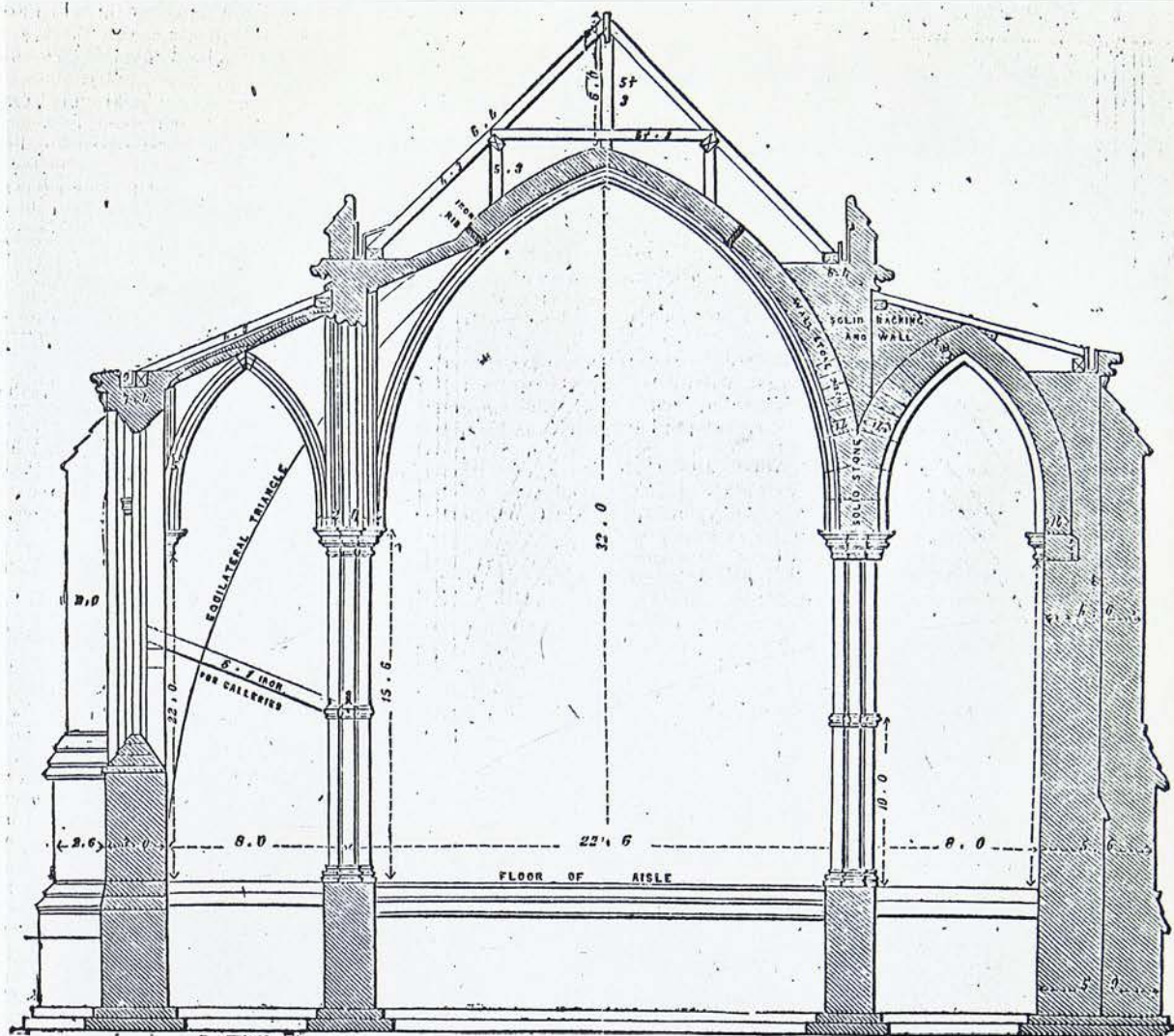
It was built in 1840,<sup>1</sup> at the sole expense of the neighbouring Bowling Iron Works "for the use of their numerous workmen and the surrounding population."<sup>2</sup> The 'Early English' design was provided by Richard and Samuel Sharp.<sup>3</sup> The construction was a combination of iron and stone with the exception of the timber roof. Iron was used for the pillars and for all the ribs of the vaults and the interstices of the vaults were filled with stone. (See Plate 64). The nave pillars, which were 15 feet 6 inches high, were constructed

<sup>1</sup> Ware gives 1842. The evidence of Richard Sharp's letter published in the *Civil Engineer and Architect's Journal* is to be preferred. (December 28th 1850).

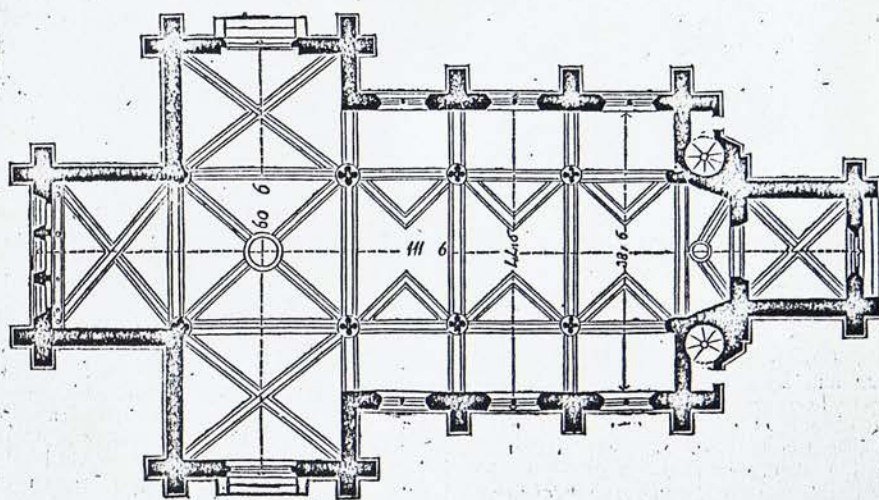
<sup>2</sup> *Civil Engineer and Architect's Journal*, December 28th 1850, p. 41.

<sup>3</sup> Richard Henry Sharp and his younger brother Samuel had an architectural practice in York. See Colvin, p. 536 and Ware, p. 214.





Cross Section.—Scale  $\frac{1}{4}$ -inch to the foot.



Plan of the Church.

Plate 64. St. John's Church, Bowling, near Bradford, by R. H. and S. Sharp, 1840. Plan and cross section.



of a central column of 8 inch diameter surrounded by four smaller columns of  $4\frac{1}{2}$  inch diameter linked together at the top by the capital and at the bottom by the base and by a fillet moulding in the middle. (See Plate 65). The central column was increased to 12 inches diameter in the pillars at the junction of the nave and transepts where they were bearing a greater load.

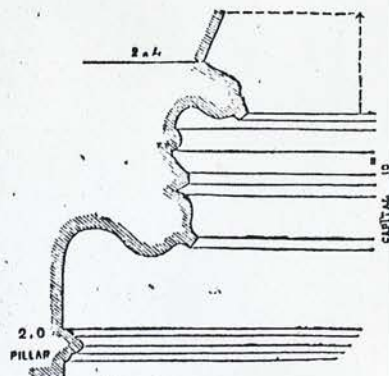
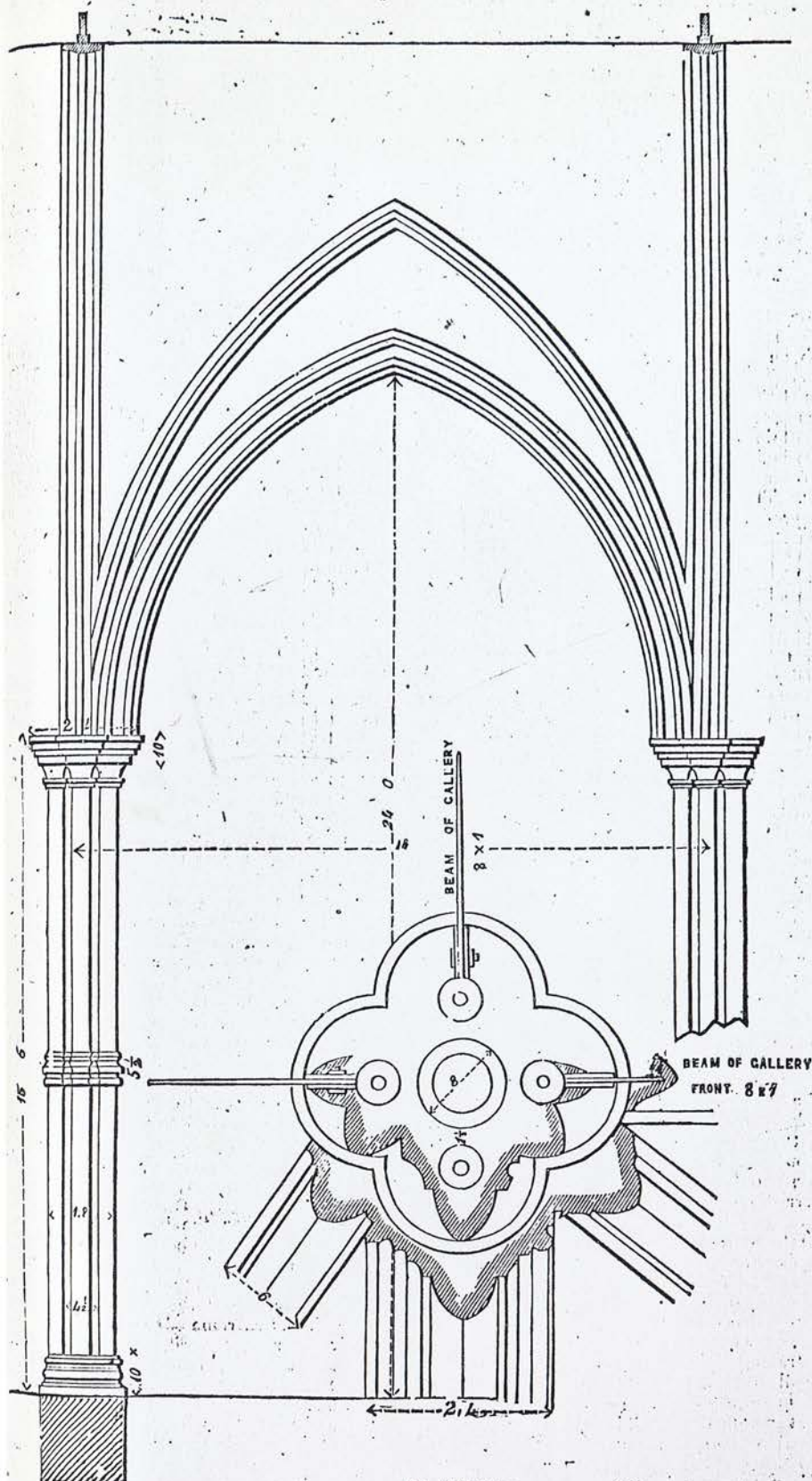
The building remains unaltered to this day and is in almost perfect condition. The iron work is a tribute to the moulders of the Bowling Iron Works who "volunteered to forego the extra price deserved for the very difficult work ... of casting the Lancet Gothic capitals and other details."<sup>4</sup>

What is surprising about St. John's is that it represented a simple method of using iron in a vaulted Gothic church which was never followed and does not seem to have been considered by the Ecclesiological Society when they were searching for a prototype iron church in the 1850's.

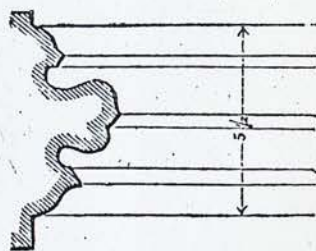
The second example of iron applied to church building in the 1840's was of an entirely different character. As part of Edward Blore's alterations at Buckingham Palace, the South Conservatory<sup>5</sup> was converted into a chapel in 1842-3. (See Plate 66). In the alterations the conservatory windows were walled up and the roof was

<sup>4</sup> Civil Engineer and Architect's Journal, December 28th 1850, p. 41.

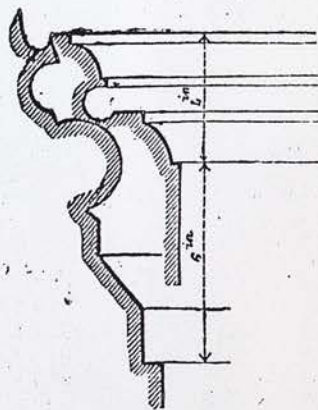
<sup>5</sup> Three conservatories in the form of 'Greek temples' were built as part of John Nash's work at the Palace between 1825-30. Iron was used in many parts of Nash's work. See *Mechanics' Magazine*, July 28th 1827, pp. 17-25 and December 22nd 1827, pp. 353-5. After Blore's appointment in 1831, the North Conservatory was removed and re-erected at Kew.



Section of Mouldings of Capital.



Section of Middle Pillets of Column.



Section of Base and Stone Plinth.

The Mouldings are drawn to one-sixth the fullsize.

Plan of Pillars.  
The Pillars at the Angles of the Transept are 12 inches diameter.



Plate 66. Royal Chapel, Buckingham Palace, by Edward Blore, 1842-3.



raised to admit light by clerestories at the East and West ends.

There is some mystery as to the extent to which Nash's ironwork was re-used in Blore's alterations.<sup>6</sup> Because the roof was raised it seems certain that the 25 feet columns were new but it seems likely that the cast iron beams were re-used, as the design of these corresponds with the stonework details on the original exterior of the conservatory.<sup>7</sup>

The total effect of the alterations was, however, very chaste and elegant. The interior was painted in "white and French white and relieved by crimson fittings",<sup>8</sup> the columns in "white with gilt capitals."<sup>9</sup>

Unfortunately neither royal patronage nor consecration by the Archbishop of Canterbury<sup>10</sup> could effect a general acceptance of the use of iron in church buildings in the manner that had been so elegantly demonstrated at Buckingham Palace.

Nevertheless in the mid 1840's iron churches of a very simple and utilitarian character started to be manufactured for export to the rapidly expanding colonial territories. Typical of these early experiments was an iron church manufactured by Peter Thompson

<sup>6</sup> Illustrated London News, April 8th 1843, p.235.

<sup>7</sup> See Thomas Shepherd's drawing of 1825 in T.Davis, John Nash, 1966 Plate 75.

<sup>8</sup> Illustrated London News, April 8th 1843, p.235.

<sup>9</sup> H. Clifford Smith, Buckingham Palace, 1931, p.197.

<sup>10</sup> 25th March 1843.



in London and sent out to Jamaica in 1844. (See Plate 67). The pilasters were of cast iron supporting a wrought iron roof structure covered in corrugated iron<sup>11</sup> with a ceiling in panels with felt insulation.<sup>12</sup>

The advantages of cheapness and speed of erection that these buildings offered, soon recommended itself to the home market. During the 1850's it became common practice to erect temporary iron churches in the rapidly growing suburbs of London.

Two manufacturers were the leading suppliers of these churches - Samuel Hemming and Co. and Messrs. Tupper.<sup>13</sup> Hemming's church at Kensington<sup>14</sup> was apparently the first of its kind in London. (See Plate 68). Although described as an iron church, timber was used extensively in the interior. The exterior was entirely covered in corrugated iron with a cast iron verandah at the west end. Iron castings were used for the window frames and all the decorative details on the exterior.

Maintenance on such a building presented a special problem but on St. Paul's a most ingenious arrangement was worked out. Five shillings for each sitting<sup>15</sup> per year was paid to the contractor

<sup>11</sup> Corrugated iron was coming into common use at this time. The first recorded instance of its use was Fairbairn's Corn Mill at Constantinople, 1839-41. See Chapter VI.

<sup>12</sup> The problems of iron buildings in tropical climates seem to have been understood from the start. Later a double skin construction with a ventilated air space was common.

<sup>13</sup> Examples are mentioned in the Civil Engineer and Architect's Journal, 1857, p. 236: The Building News, February 27th 1857, p. 221: The Builder, May 12th 1860, p. 304 and September 8th 1860, p. 583.

<sup>14</sup> St. Paul's temporary (iron) Church, Kensington, The Builder, October 27th 1855, pp. 507-8.

<sup>15</sup> The church held 800 people.

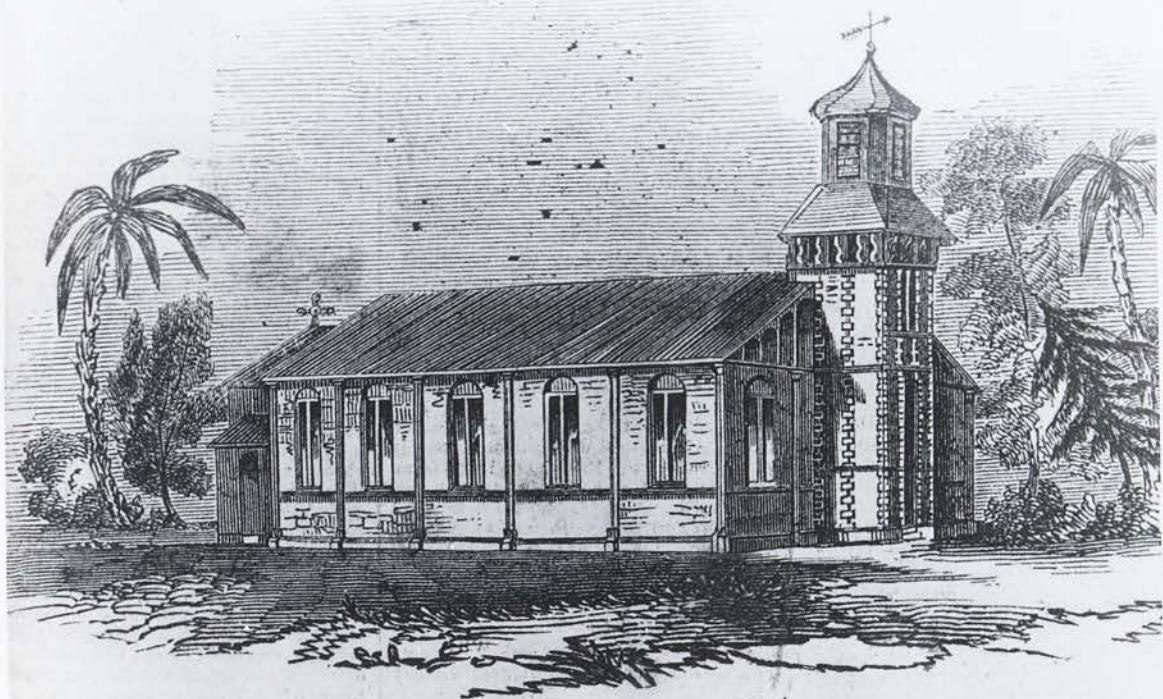


Plate 67. Iron church for Jamaica by Peter Thompson, 1844.

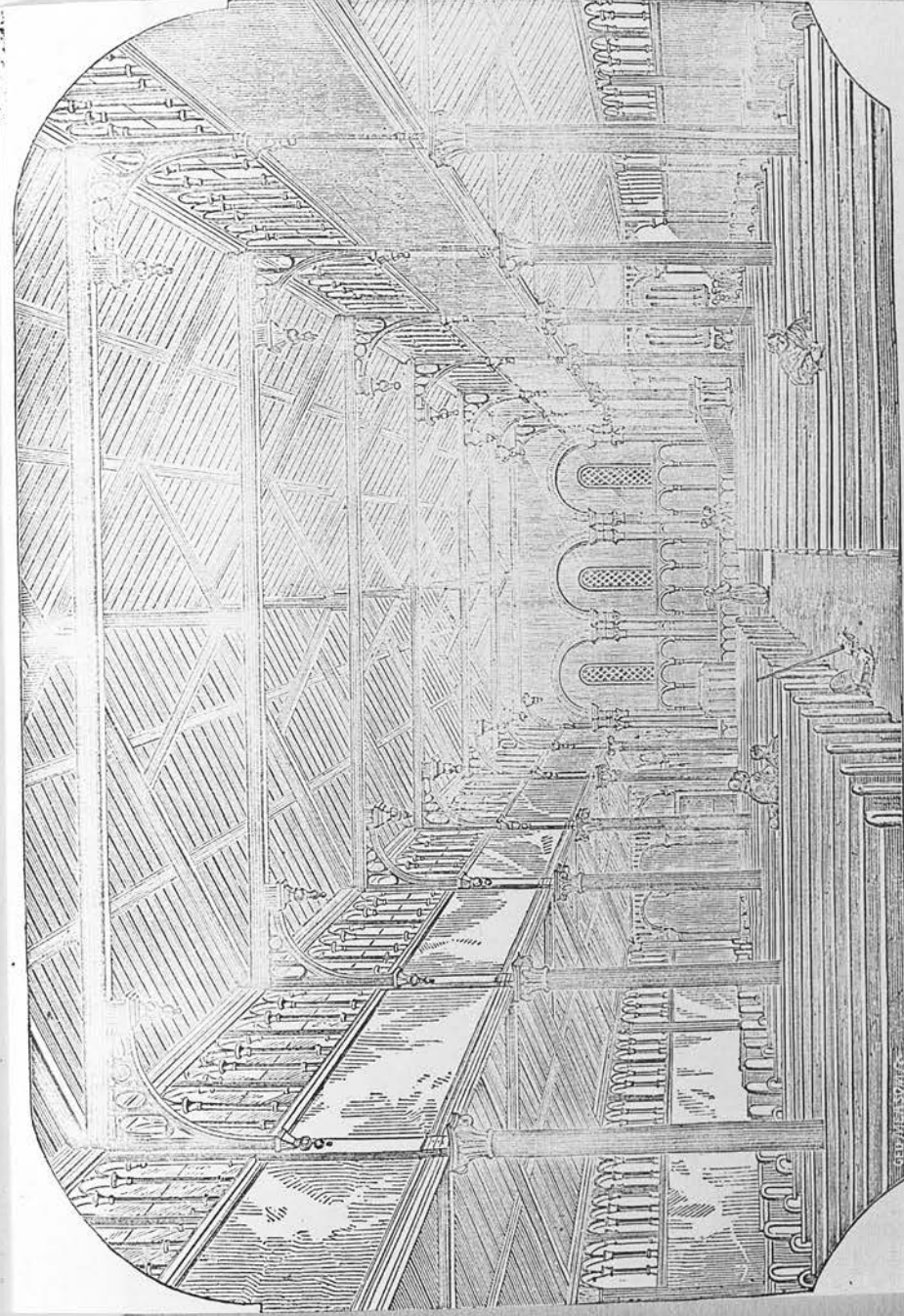


Plate 68. St. Paul's temporary (iron) Church, Kensington, by Samuel Hemming and Co., 1855.



for maintenance. If the proceeds did not meet the annual expenses the deficiency was made up by the Archdeacon and if there was a surplus, it was put into a fund for a permanent building of stone.

These temporary churches were harshly criticized and frequent pleas appeared in architectural journals for something to be done to make them more "worthy in architectural character."<sup>16</sup> One writer described such a church as giving the impression to strangers that it was "a galvanized iron coke shed".<sup>17</sup>

The remedy for such ugliness was to "engage an experienced designer to furnish . . . drawings and details for such a structure".<sup>18</sup> Such a step was taken by the Ecclesiological Society when they commissioned R. C. Carpenter to design a prototype iron church. After Carpenter's death in 1855 his pupil William Slater carried on with the project and presented his design to the Society in 1856. Their aim was "to show how a church-like building may be constructed in iron, without, on the one hand abandoning architectural forms, or, on the other, violating the essential laws which ought to regulate the employment of this, or indeed of any, material."<sup>19</sup>

The plan shows a simple arrangement of nave and aisles with a chancel of apsidal form. (See Plate 69). The external walls

<sup>16</sup> C. DeFe, Iron Churches, The Builder, September 11th 1858, p. 622.

<sup>17</sup> "B", Iron Churches, The Building News, November 30th 1860, p. 911.

<sup>18</sup> C. DeFe, op. cit., p. 622.

<sup>19</sup> Instrumenta Ecclesiastica, Second Series, 1856, description of Plate LXVII.

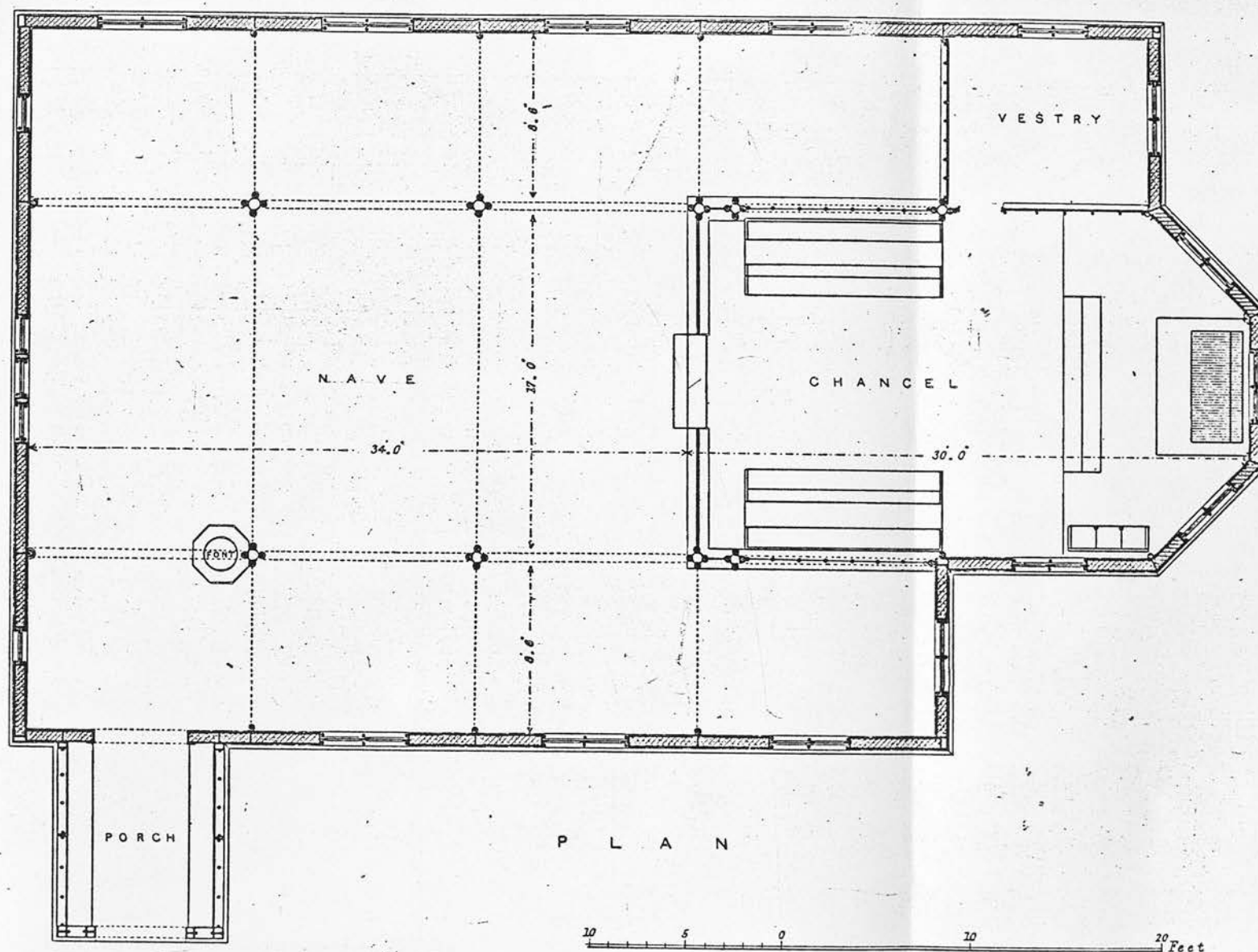


# Iron Church.

INSTRUMENTA ECCLESIASTICA

Second Series. PLATE 67.

Ecclesiological late  
Cambridge Camden Society.



W. Slater, del<sup>t</sup>

G. B. Smith, sc.

Plate 69. The Ecclesiological Society's Iron Church, by William Slater, 1856. Plan.

were constructed of a framework of iron with panels consisting of two plates of corrugated iron packed with felt and sand. The longitudinal section clearly shows the decorative treatment of the interior. (See Plate 70). The main pillars are composed of four slender columns tied together in a similar manner to St. John's Bowling. The main pointed arches of the nave are made up of cast iron sections with perforated webs and the spandrils over these are filled with thin cast iron plates with a fretted geometric design. (See Plate 71). Although the exterior was very plain (See Plate 72), the interior (See Plate 73) was intended to be highly decorative, perhaps more extravagantly so than the drawings suggest. F. Skidmore described his ideas for the interior in a letter, when he submitted an estimate for the church.<sup>20</sup>

He argued that iron should be "used as our forefathers used every material of their day, giving it a natural expression, adding art and beauty to the constructive form."<sup>21</sup> For this church he suggested "the use of geometrical forms of iron ... filled in with marble of various colours: as also carving or ceramic art for the same purpose. The interior would afford ample scope for carrying out that floral treatment so much used in the 14th century. The iron also would require coating with pigments to preserve its surface, and would form a ready means of illumination: the renewed use of crystals

<sup>20</sup> Skidmore estimated the cost as £2,500 - one third of the cost of a stone church of comparable size. See *The Ecclesiologist*, Vol. XVII, 1856, p. 134.

<sup>21</sup> Instrumenta Ecclesiastica, description of Plate LXXII.

# Iron Church.

INSTRUMENTA ECCLESIASTICA

Second Series. PLATE 68.

*Ecclesiological Institute*  
Cambridge Camden Society.

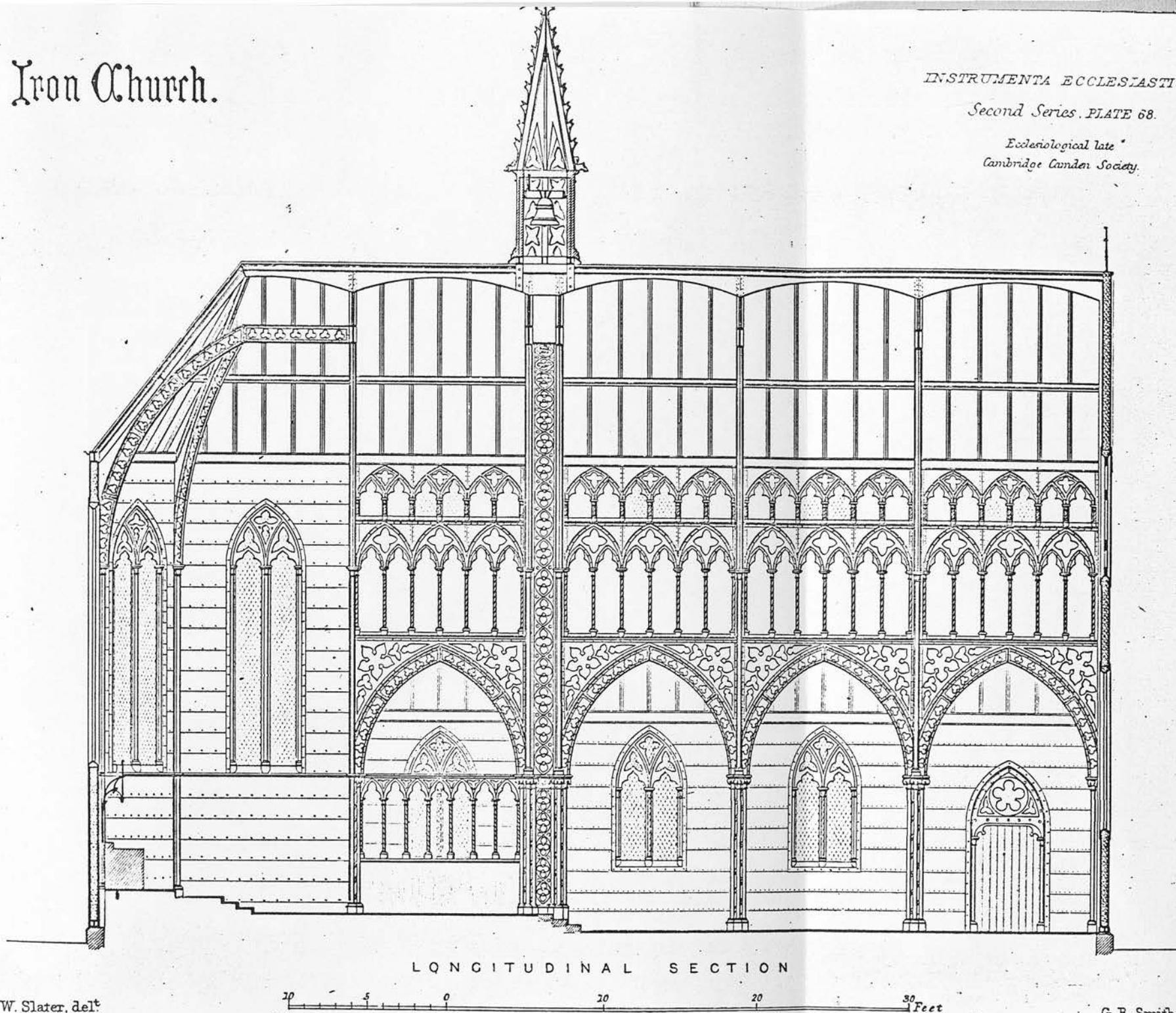


Plate 70. The Ecclesiological Society's Iron Church.  
Longitudinal section.

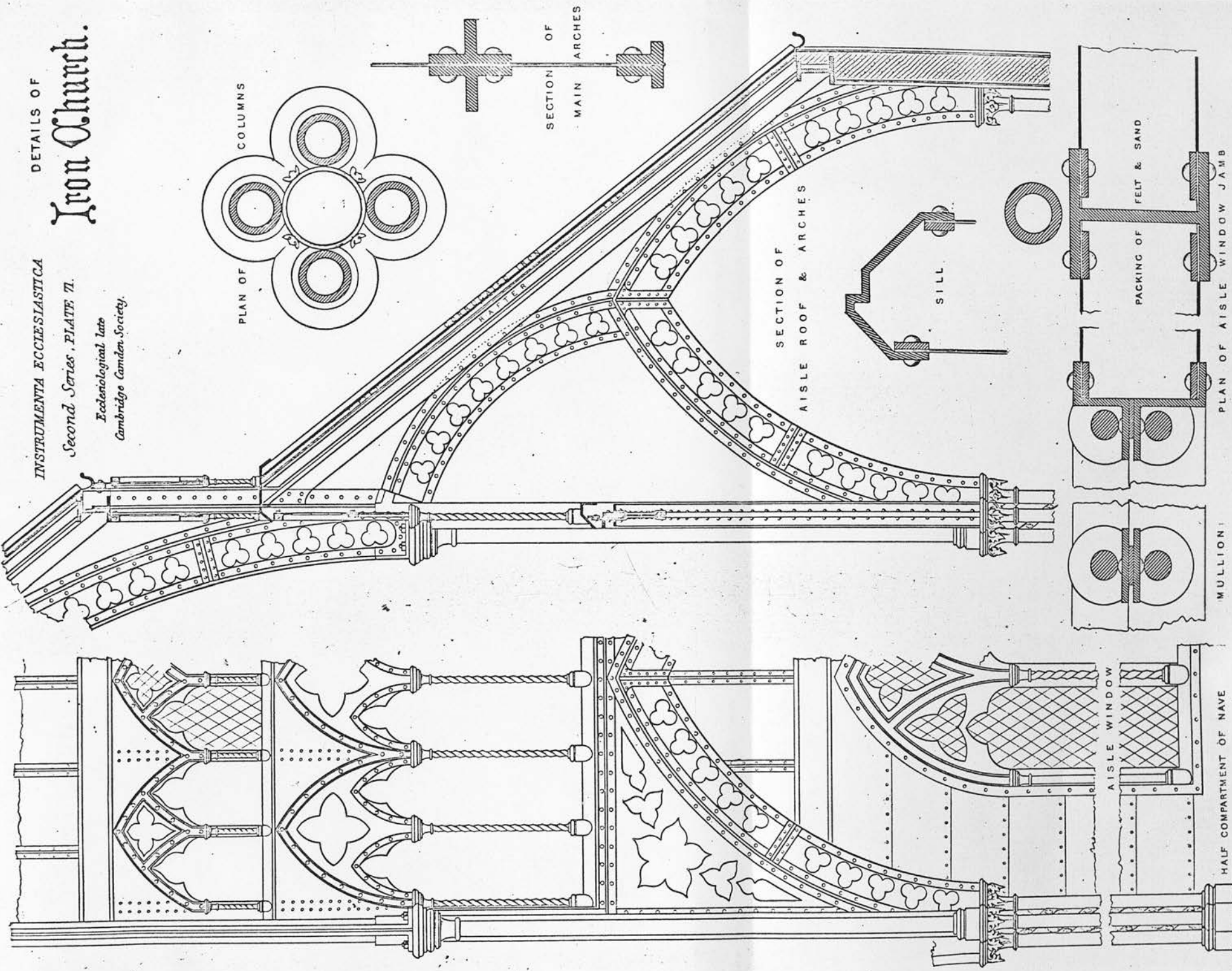


# DETAILS OF **Iron Church.**

INSTRUMENTA ECCLESIASTICA

Second Series, PLATE 71.

*Ecclesiological Institute  
Cambridge Camden Society.*



W. Slater. del.

London: John Van Voorst, Paternoster Row.

G. B. Smith. sc.

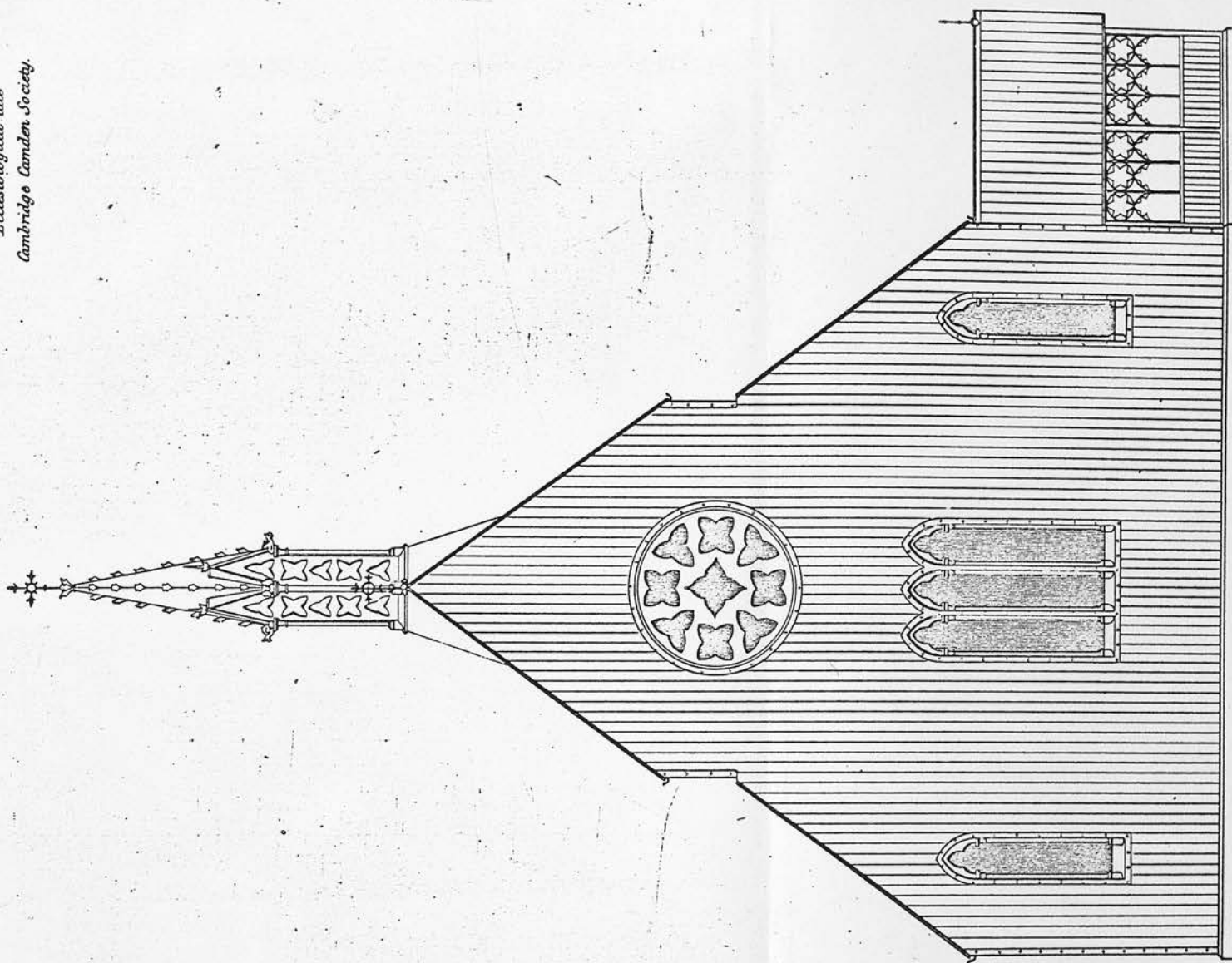


# Iron Church.

INSTRUMENTA ECCLESIASTICA

Second Series, PLATE 69.

*Ecclesiological Institute  
Cambridge Camden Society.*



WEST ELEVATION

10 5 0 10 20 Feet

W. Slater, del.

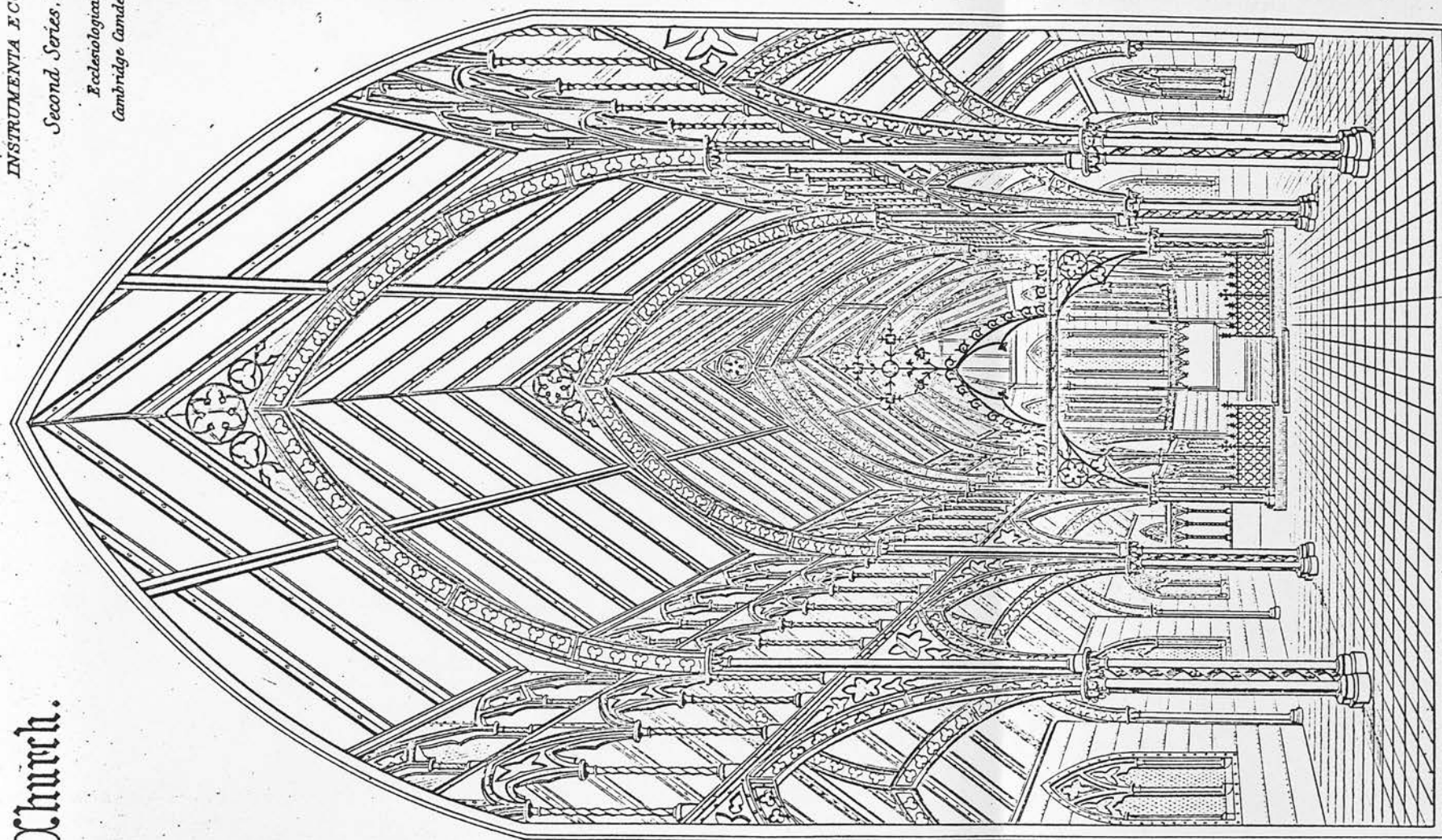
G. B. Smith, sc.

# Iron Church.

INSTRUMENTA ECCLESIASTICA

Second Series, PLATE 72.

*Ecclesiological Institute  
Cambridge Camden Society*



INTERIOR VIEW

W. Slater, del.

G. B. Smith, sc.

Plate 73. The Ecclesiological Society's Iron Church.  
Interior perspective view.

and gems, as in ancient metal work: the use of enamels . . . .: the covering wall surfaces with tapestry."<sup>22</sup> Skidmore's hope, like Ruskin's for the Oxford Museum, was that it would "serve to inaugurate the use of metal, combining the artistic skill and manipulative powers of our day."<sup>23</sup> Unfortunately nothing came of this project which might have answered Ruskin's hope for "lovelier and juster expressions of the Gothic principle."<sup>24</sup>

After the publication of this project some attempt was made by the iron church manufacturers to enrich their designs. Samuel Hemming's iron church exhibited at the International Exhibition of 1862 shows a remarkable resemblance to Slater's church.<sup>25</sup> (See Plate 74). Such designs do not seem to have gained favour mainly because of their higher cost<sup>26</sup>.

More typical of iron church building in the second half of the 19th century was the simple corrugated shed-like building with all the meanness of appearance and detail of the examples that were common before the Ecclesiological Society's efforts. It was this kind of building that led to Ruskin's remark that "of all manner of churches thus idiotically built iron churches are damnablest to me."<sup>27</sup>

<sup>22</sup> Ibid.

<sup>23</sup> Ibid.

<sup>24</sup> See Chapter IV note 52

<sup>25</sup> Official Illustrated Catalogue of the International Exhibition 1862, Vol. II, p. 19.

<sup>26</sup> Frequent advertisements in the architectural journals give the price of iron churches as 20 shillings per sitting. This was about a third of the cost of Slater's church.

<sup>27</sup> Quoted in the American Architect and Building News, January 1888.



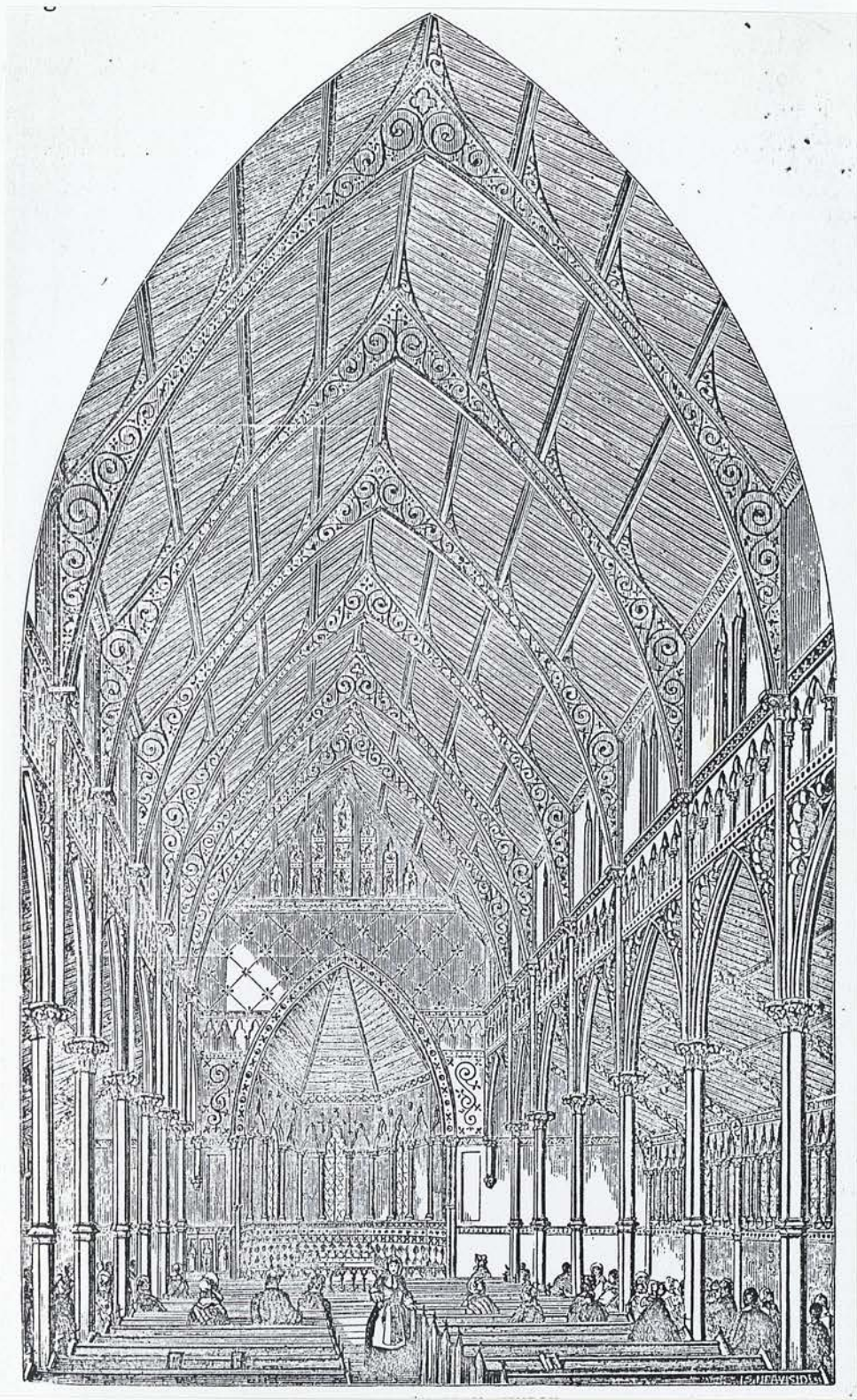


Plate 74. Iron Church by Samuel Hemming and Co., 1862.  
Interior perspective view.



The first examples of exported portable buildings were constructed in Dundee. The earliest experiment occurred soon after Arthur Phillip had established the first penal colony in Australia at Sydney Cove. To replace a miserable collection of tents that had served as a sick bay, a timber portable hospital arrived from England in 1790.<sup>1</sup> The design for this 'moveable hospital' had been prepared by Samuel Wyatt in 1788 for use in 'His Majesty's distant possessions'.<sup>2</sup> Timber houses were also sent out to South Africa soon after the English settlers arrived in Port Elizabeth in 1820.<sup>3</sup> Later it seems that it was fairly common for potential emigrants to buy a small prefabricated house before they set off.<sup>4</sup>

Although the principles for prefabricating an iron structure

## CHAPTER VI

had been so widely described by Thomas Paine as far back as 1793,

### The export of portable iron buildings from Britain (1839-80)

It was not until 1840 that the first portable iron building was exported from Britain by William Fairbairn.

Fairbairn was commissioned after the Duke of Devonshire had sent a group of officers to England in 1839 to investigate the possibilities of building iron buildings in India.

<sup>1</sup> Morton Harrison, *The Early Australian Aesthetic and their work* (Sydney, 1954), pp. 7-8 and 12.

<sup>2</sup> A. W. Skempton, *Samuel Wyatt and the Eighteenth Century Architectural History*, Vol. 1, 1971, p. 31.

<sup>3</sup> *Ibid.*, p. 32.

<sup>4</sup> Ronald Leach, *Early Nineteenth Century Architecture in South Africa*, Cape Town, 1963, p. 101.

<sup>5</sup> *Temporary cottages for Australia*, *Mechanics' Magazine*, May 19th 1832, pp. 27-9.

<sup>6</sup> See Chapter I.

The first examples of exported portable buildings were constructed in timber. The earliest experiment occurred soon after Arthur Philip had established the first penal colony in Australia at Sydney Cove. To replace a miserable collection of tents that had served as a sick bay, a timber portable hospital arrived from England in 1790.<sup>1</sup> The design for this 'moveable hospital' had been prepared by Samuel Wyatt in 1788<sup>2</sup> for use in "his Majesty's distant possessions".<sup>3</sup> Timber houses were also sent out to South Africa soon after the English settlers arrived in Port Elizabeth in 1820.<sup>4</sup> Later it seems that it was fairly common for potential emigrants to buy a small prefabricated house before they set off.<sup>5</sup>

Although the principles for prefabricating an iron structure had been so lucidly described by Thomas Paine as far back as 1788, and the iron bridge sent to Jamaica in 1800 had been such a success,<sup>6</sup> it was not until 1840 that the first portable iron building was exported from Britain by William Fairbairn.

Fairbairn was commissioned after the Sultan of Turkey had sent a group of officers to England in 1838 to investigate the state

<sup>1</sup> Morton Herman, The Early Australian Architects and their work, Sydney, 1954, pp. 7-8 and 12.

<sup>2</sup> A. W. Skempton, Samuel Wyatt and the Albion Mill, Architectural History, Vol. 14, 1971, p. 57.

<sup>3</sup> Ibid., p. 57.

<sup>4</sup> Ronald Lewcock, Early Nineteenth Century Architecture in South Africa, Cape Town, 1963, p. 191.

<sup>5</sup> Temporary cottage for Australia, Mechanics' Magazine, May 19th 1832, pp. 97-8.

<sup>6</sup> See Chapter I.

of "the mechanical and useful arts in England."<sup>7</sup> After their visit to Fairbairn's works in Manchester and London, he was invited to Turkey to advise on many aspects of industrial development. "The visit" says Fairbairn, "eventually led to large orders which I executed for the Government after my return".<sup>8</sup> The first of these was an order for a corn mill, complete with its machinery, for Constantinople. For fireproofing reasons, Fairbairn chose a structure of iron plates bolted to pilasters at 7 feet centres and tied by an external girder at first floor level.<sup>9</sup> (See Plate 75). Although the entire wall structure was composed of heavy castings (about 1½ inches thick) the roof was an interesting innovation in lightweight construction. Corrugated iron was used in a curved form which required no intermediate support over the 25 feet span. This was to become a standard feature of short span industrial structures that were exported throughout the 19th century.

Another technique for exported iron buildings was established by this building. The structure was cast and erected in Fairbairn's works in Millwall in 1839,<sup>10</sup> and then dismantled, packed and shipped to Constantinople the following year. It was standard practice with all subsequent exported iron buildings that the assembly was tried out in Britain before the building was shipped.

<sup>7</sup> William Pole, The Life of Sir William Fairbairn, 1877, p. 167.

<sup>8</sup> Ibid., p. 172.

<sup>9</sup> David Scott, The Engineer and Machinist's Assistant, 1847, Vol. I, pp. 85-92 and Vol. II, Plates XVIX-CV. See also William Fairbairn, Treatise on Mills and Millwork, 1861-3, Vol. II, pp. 118-25.

<sup>10</sup> William Fairbairn, Useful Information for Engineers, Second Series, Second Edition, 1867, p. 82.

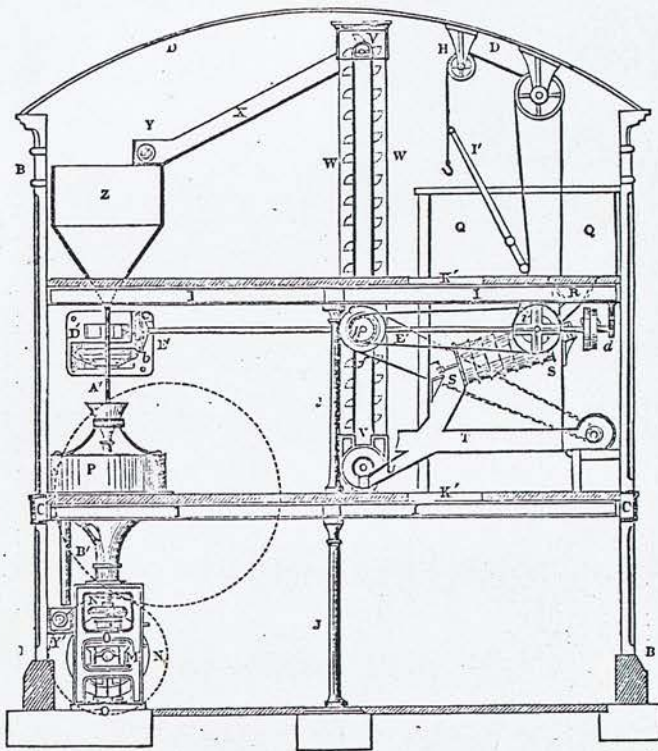
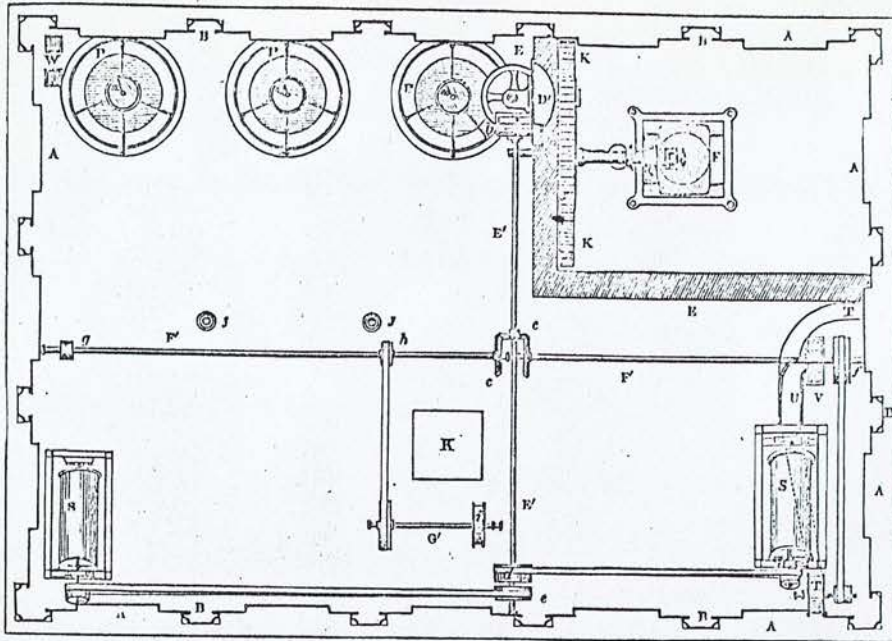


Plate 75. Corn Mill, Constantinople, by Sir William Fairbairn, 1839-42. Plan at first floor level and cross section.



The next recorded example to leave England was a far less utilitarian structure. This was a palace for a West African king whose lands surrounded the Calabar River. Although King Eyambo was the proud possessor of three hundred and twenty wives, his palace was a rather modest building, probably intended for state business and not used as a residence. It had two principal storeys and was 60 feet long by 40 feet wide. (See Plate 76). It was manufactured by William Laycock in his works in Oldhall Street, Liverpool and was erected in a nearby open space where it was opened to public exhibition (for the benefit of charities) before being shipped to Africa in 1843. No technical description of the building exists but it would seem to have been fabricated from iron plates attached to a timber frame with an internal lining of richly decorated timber.<sup>11</sup>

It is most remarkable that the unselfconscious style of this building was praised by the editor of the Builder.<sup>12</sup> He saw it as an example of the "emanative principle" - a rational style born of "construction in its modes and material, climate requirements .... and by them fed and nourished."<sup>13</sup>

In the following year Laycock sent a more modest building to the West Indies - "an iron cottage for the use of two maiden ladies

<sup>11</sup> The Builder, 13th May 1843, p. 171.

<sup>12</sup> Ibid., p. 170. The editor at this time was the founder of the journal, Joseph Hansom.

<sup>13</sup> Ibid., p. 170. *Eyambo's Palace (Calabar) Nigeria, by William Laycock, 1843.*

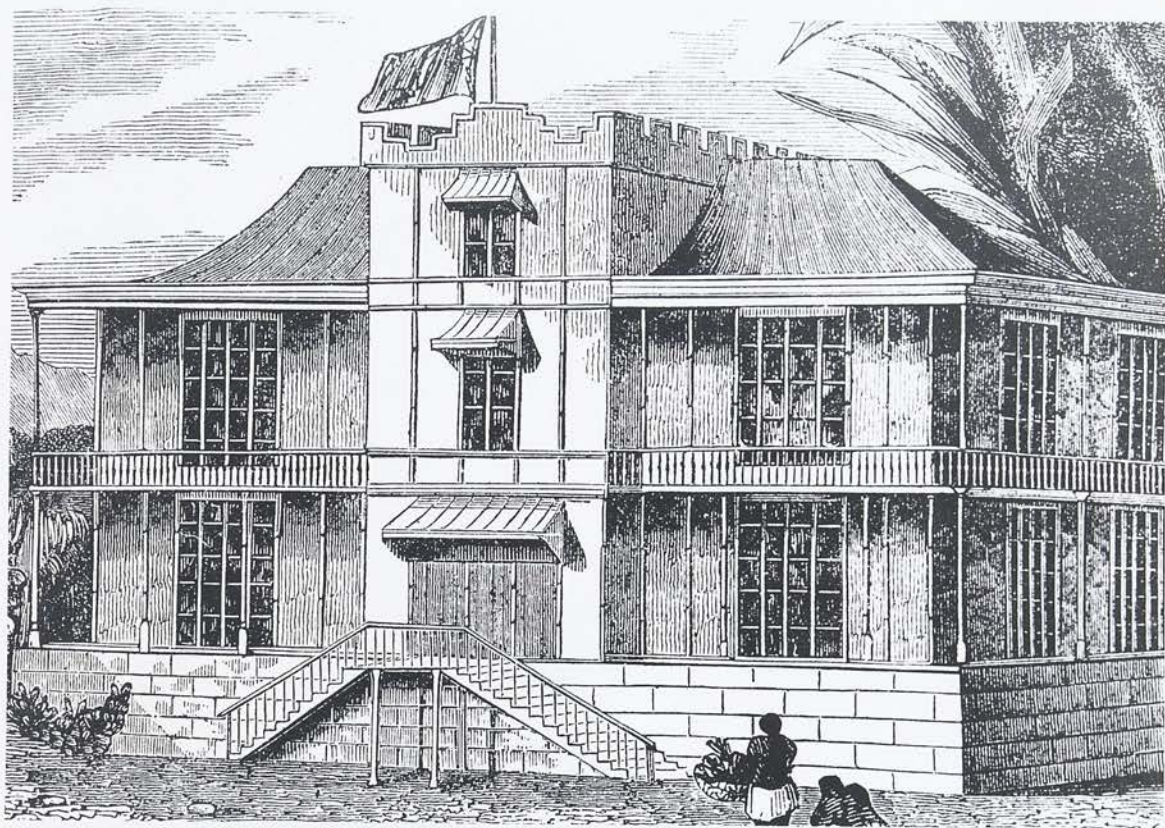


Plate 76. King Eyambo's Palace (Calabar) Nigeria, by William Laycock, 1843.

residing in the island of St. Lucia." <sup>14</sup> No drawing of this building exists, but from the description it can be deduced that it was of iron except for the "jalousy windows and the floor". <sup>15</sup>

The design attempted to deal with the problems of an iron building in a tropical climate. The walls were formed of double plates of iron with an air space between. The contemporary description is quite explicit as to the reason for this. It "will prevent the passing of the solar heat into the interior of the building . . . . and keep the interior delightfully cool." <sup>16</sup> The roof was designed to act in a similar way - the outside covered in plates of galvanized iron and the inside had a ceiling of panels of iron.

In 1845 H. and D. Grissell of London sent out to Mauritius a collection of iron portable buildings which were designed to deal with the climatic problems in an even more sophisticated way. <sup>17</sup> This collection of buildings, for a military station, consisted of officers' quarters, a hospital and a lazaretto, all designed using the same constructional system.

The walls were fabricated from 'H' section frames which were clad inside and out with wrought iron plates leaving an air gap. The roof was of cast iron in a segmental form, with wrought iron 'T' section purlins supporting cast iron plates. The ceiling

<sup>14</sup> Mechanics' Magazine, December 7th 1844, p.400. See also the Builder, December 14th 1844, p.623.

<sup>15</sup> Ibid., p.400.

<sup>16</sup> Ibid., p.400.

<sup>17</sup> The Builder, March 18th 1851, pp.152-3.



below was formed of ornamental cast iron bearers supporting wrought iron sheet panels. The innovation to improve the thermal performance of the building was in the design of a minor detail in the design of the roof. "The apex of the roof was covered with a cast-iron ridge roll so as to keep out the weather, but so formed as to leave an open ventilating space the whole length of the roof, the object being, as in that hot climate the heat upon the roof would be so great as to rarefy the air in the ceiling space, to allow it to pass out at the opening left in the ridge roll, and to draw a succession of cooler and passing air through the hollow walls, which would thus keep the rooms cooler than they otherwise would be."<sup>18</sup>

The use of iron as a cladding material was greatly extended, firstly, by employing galvanizing as a method of preservation<sup>19</sup> and secondly, by using corrugated plates.<sup>20</sup>

The first firm to exploit galvanized corrugated iron in an extensive way was J. H. Porter of London. Porter used the material in a very simple way in curved sheets in arched roof forms. Plate 77 shows a typical example of this type of building with a roof span of 46 feet which required "no internal framing, but simply tension rods to counteract the thrust of the arch."<sup>21</sup> The cheapness, lightness and rigidity of this form of construction led to an extensive

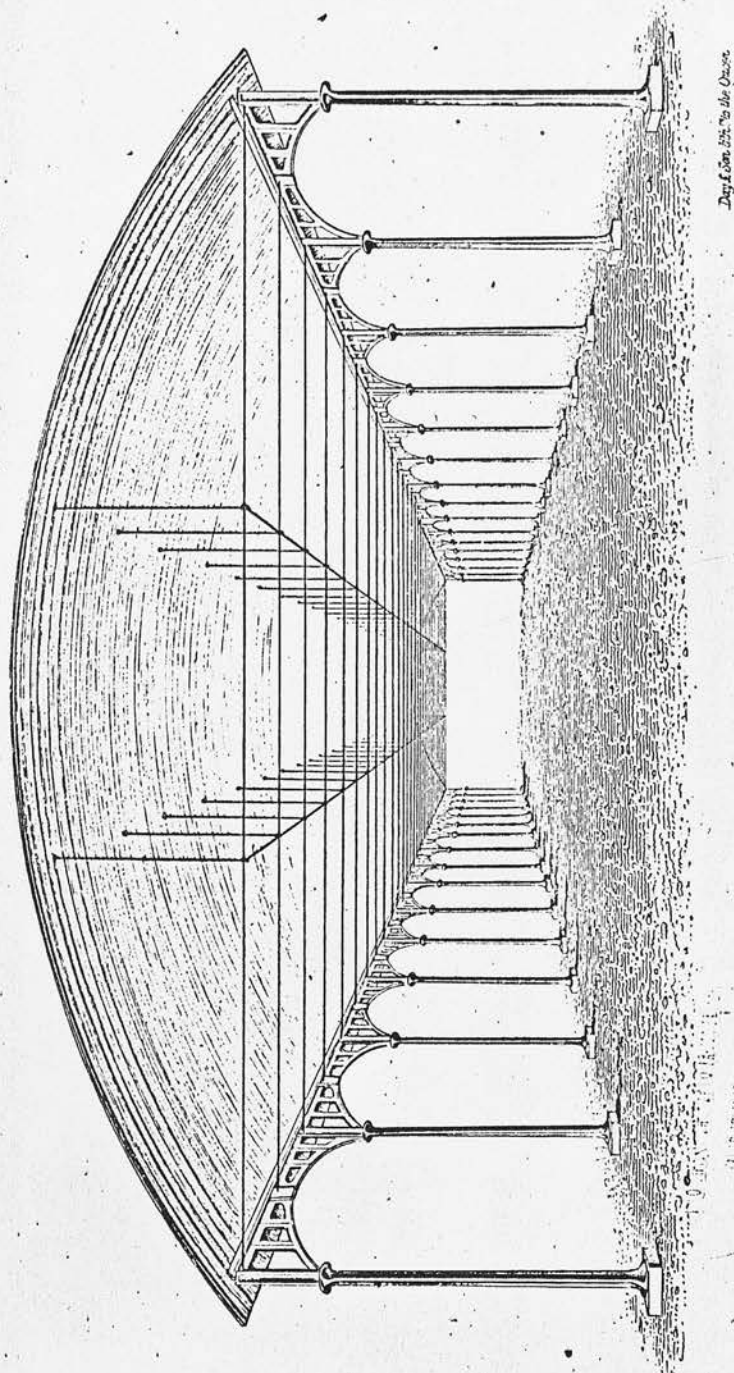
<sup>18</sup> Ibid., p. 153.

<sup>19</sup> The invention of M. Sorel, c. 1842.

<sup>20</sup> Porter took out a patent using corrugated iron for floors, roofs and beams (1848) See Appendix I, No. 48.

<sup>21</sup> Examples of Iron Building and Roofing, manufactured by John H. Porter, 1849, p. 4.





*Designed by the Queen*

IRON SHED, PATENT FUEL COMPANY,  
SWANSEA,  
1847.

Plate 77. Iron shed, Swansea, by John H. Porter, 1847.

trade for John Porter in exported buildings. (See Appendix I).

Although it did not use the arched form of roof, Porter's most handsome building, a market house sent to San Fernando on the island of Trinidad in 1848, has all the same characteristics. (See Plates 78 and 79). This building was 80 feet long and based on a bay width of approximately 7 feet.<sup>22</sup> The main columns, in the form of pilasters with pedestals, were of 'H' section (See Fig. 5, Plate 79) joined together at their tops by a trellis pattern beam of welded wrought iron. Between the columns were fitted panels of louvres and below these were panels of corrugated iron. (See Fig. 4, Plate 79).

Because of the very light cladding and the slender wrought iron roof, the total weight of the building was only 22 tons. The cost of the building delivered to the docks in London was £550, and only £100 was added to this price for shipment, unloading and re-erecting in the West Indies.

Although this may seem a rather small amount to be added for transporting and erecting a building at such a great distance from Britain, the cost fell well below this level as the manufacturers and shippers became more experienced in this type of trade.

The use of corrugated iron for small portable houses grew rapidly in popularity when there was a sudden need for temporary housing in some distant territory. The California Gold Rush of

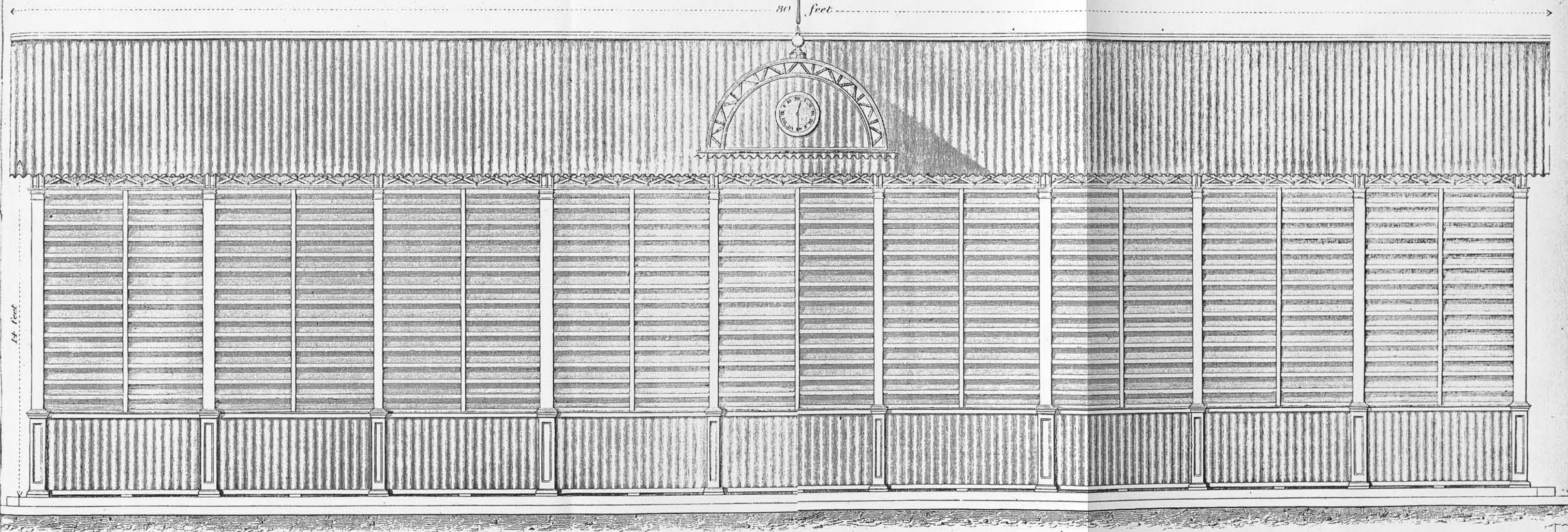
<sup>22</sup> The Practical Mechanic's Journal, Vol.I, 1848-9, p. 207 and pp. 224-5.

# IRON MARKET HOUSE

AT SAN FERNANDO, TRINIDAD.

J. H. Porter Esq<sup>r</sup>

Engineer, London.



SIDE ELEVATION.



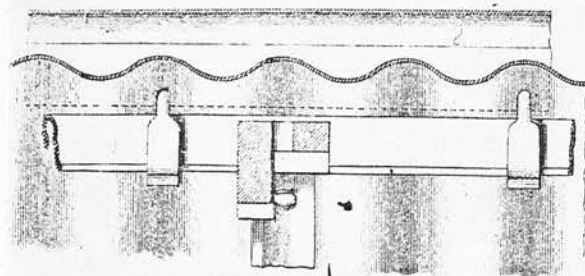


Fig. 1.

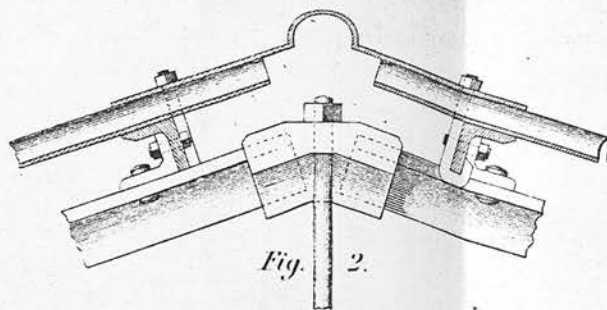


Fig. 2.

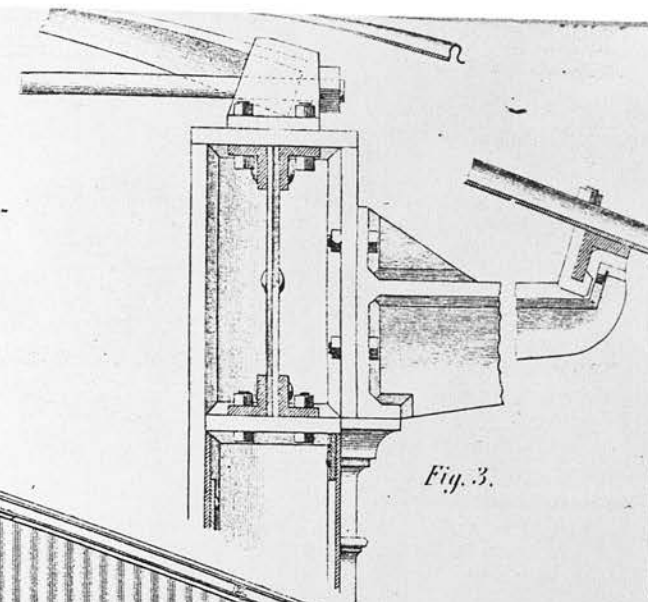


Fig. 3.

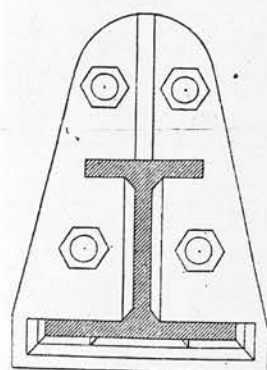
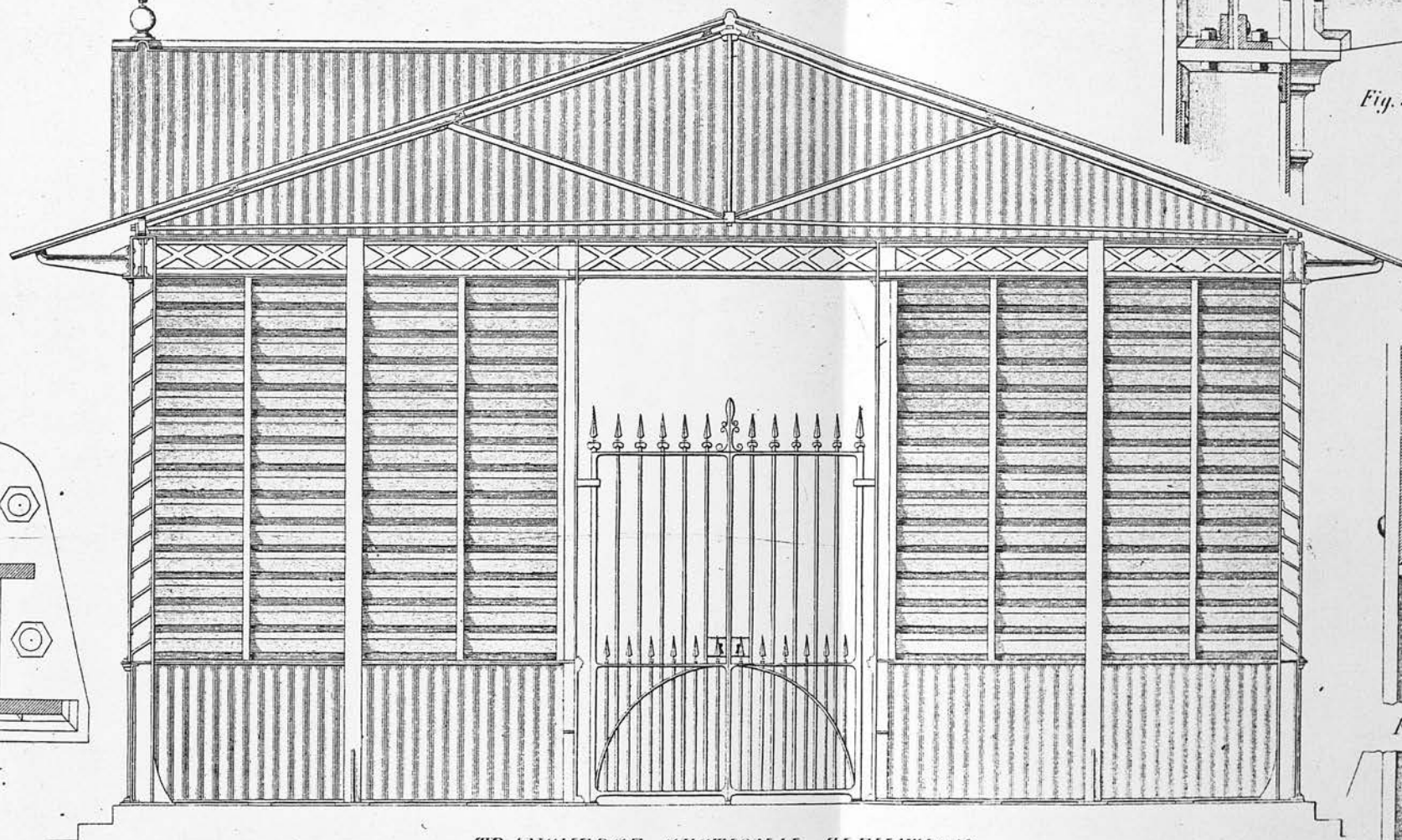


Fig. 5.



TRANSVERSE SECTIONAL ELEVATION.

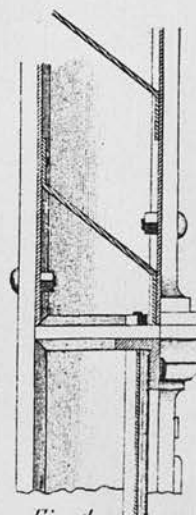
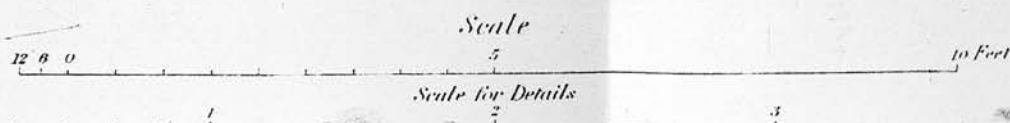
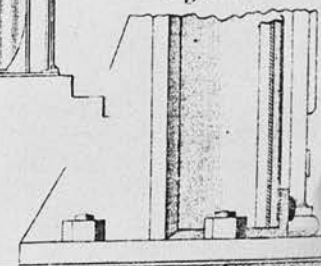


Fig. 4.



W. Johnson  
Patent Office, Glasgow



1849 caused large numbers of iron dwellings to be exported<sup>23</sup> to San Francisco. "The absence of anything like human shelter in the valley of the Sacramento, and the absolute want of lodging room for the accommodation of emigrants to San Francisco, has developed a new source of industry in this country - that of the erection of portable iron houses of various dimensions, to be shipped for California, and which can be completely put up within four days after arriving at the destined spot, and taken to pieces in twenty - four hours."<sup>24</sup>

These dwellings were usually of a very simple rectangular plan with pitched roof, constructed with either a timber or iron frame covered in corrugated iron.<sup>25</sup> Many of these were not designed with the summer climate of the Pacific coast of America in mind. "Intelligence from California does not speak favourably of iron constructions, which indeed, cannot be considered as aught but for temporary service. Exposed to a tropical sun for an entire day, they become exceedingly hot; but during the evening and especially towards morning, they cool so suddenly that their occupants

<sup>23</sup> Although these were principally shipped from Britain, they were also sent from New York and Philadelphia and several European countries. Even China, New Zealand and Tasmania contributed to this trade. See Charles E. Peterson, Early American Prefabrication, Gazette des Beaux-Arts, 1948, pp. 37-46, and Prefabs in the California Gold Rush, 1849, Journal of the Society of Architectural Historians, December 1956, pp. 318-24. A short notice of iron houses manufactured in Belgium is given in the Illustrated London News, September 15th 1849, p. 178.

<sup>24</sup> Civil Engineer and Architect's Journal, 1849, p. 319.

<sup>25</sup> Some of these designs were very modest indeed costing as little as £40 for a timber framed cottage and £70 for an equivalent design in iron. See Practical Mechanic's Journal, Vol. V, 1852-3, p. 294.

are seized with a feverish chill. Another inconvenience is that in warm weather the varnish used for protecting the iron plates from rust, emits a very unpleasant smell, and the falling of heavy rains will frighten or annoy the inmates."<sup>26</sup>

Some exporters marketed a more permanent kind of dwelling which was finished to a higher standard and had ceilings and walls lined in timber to improve the insulation. Plate 80 shows a group of three iron cottages which were manufactured by E. T. Bellhouse of Manchester.<sup>27</sup> This design used curved corrugated sheets (as used by Porter to form arched roofs), the other way up to form a pitched roof. This gave a more domestic appearance without losing the structural advantage of the curved sheet. The eaves were decorated with cast iron barge boards and the windows were given galvanised iron canopies. The casement windows were filled with diamond panes of red and orange glass. The whole building was lined with timber "to receive an ornamental paper hanging of the old English fashion".<sup>28</sup>

<sup>26</sup> Civil Engineer and Architect's Journal, 1855, p. 177.

<sup>27</sup> Allgemeine Bauzeitung, 1850, pp. 184-5. See also the Practical Mechanic's Journal, Vol. V, 1852-3, pp. 273-4. A similar design is also described in the Mechanics' Magazine, November 10th 1849, p. 442. Another Bellhouse design for an emigrant's house is given in the Illustrated London News, September 29th 1851, p. 363. This design, which was shown at the Great Exhibition, caught the attention of Prince Albert. He ordered a similar building for use as a ballroom at Balmoral. (See Plates 81 and 82). See also the Illustrated London News, November 22nd 1851, p. 613 and The Builder, September 1851, pp. 559-60.

<sup>28</sup> Practical Mechanic's Journal, Vol. V, 1852-3, p. 274.

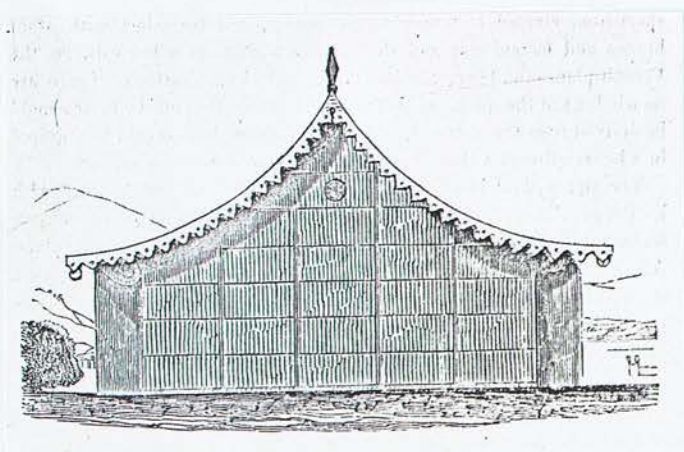
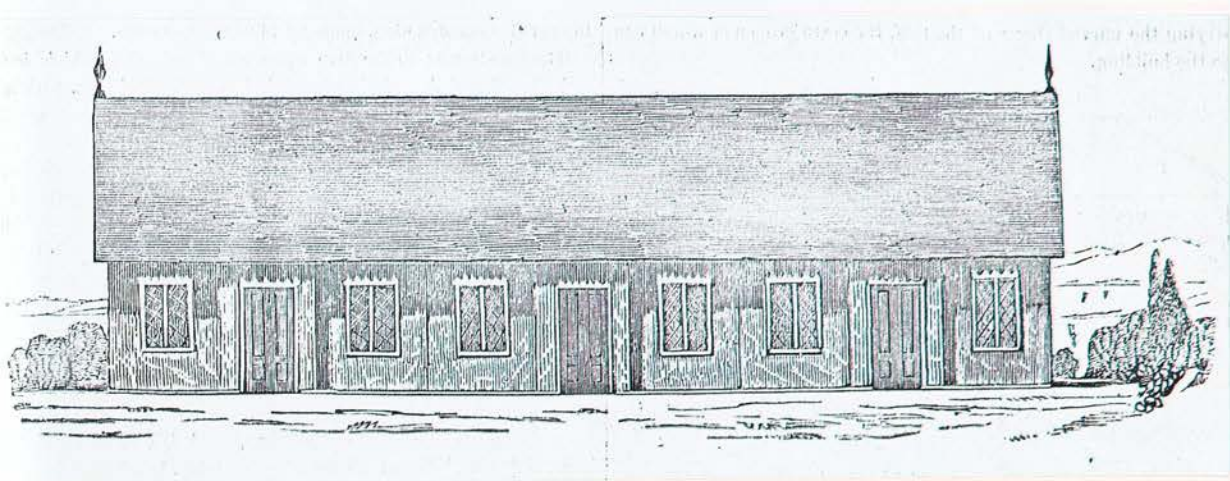


Plate 80. Iron cottages for California, by E. T. Bellhouse, c. 1850.



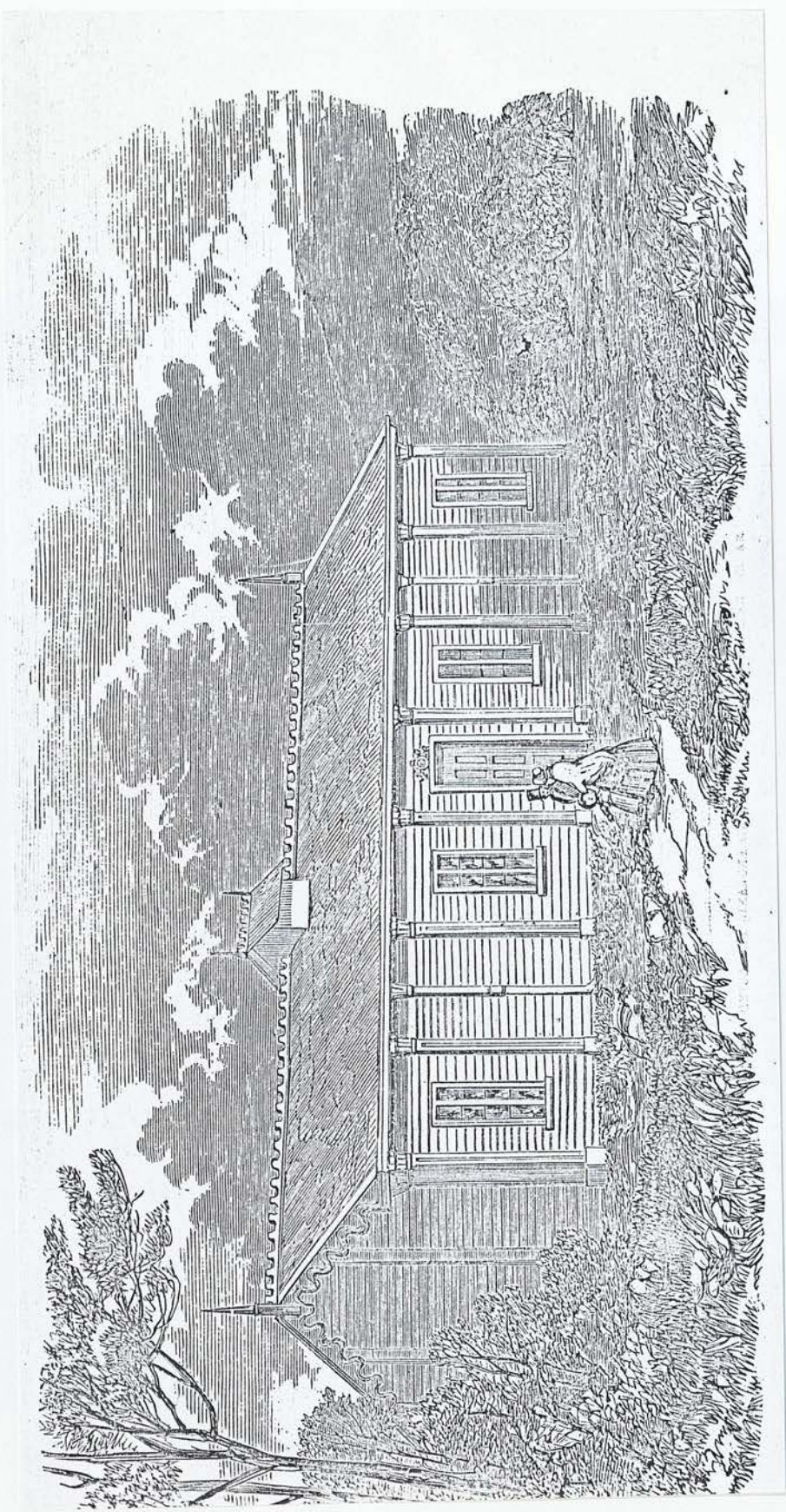


Plate 81. Iron ball-room, Balmoral, by E. T. Bellhouse, 1851.





QUEEN VICTORIA AND JOHN BROWN AT BALMORAL, 1868

The roof space was probably used for storage (notice the ventilators on the gable ends) and indeed many manufacturers produced designs for combined warehouse and domestic accommodation.<sup>29</sup> Plate 83 shows a Bellhouse design for such a building with the dwelling accommodated on part of the first floor. Although the appearance of this building is utilitarian, there is a gentle attempt to give it some architectural quality by the use of cast iron pilasters (cast in storey height lengths) with the cladding of corrugated iron neatly fitted behind these.

Bellhouse also sent out single storey warehouses to San Francisco. (See Plate 84). The published account of these gives the first description of the way in which these buildings were marked for erection. "Prior to being taken down on their preliminary erection here, each individual piece is marked with a distinguishing figure, in correspondence with reference figures on a guide-plan, prepared for the permanent erection abroad, the whole of the details are easily made out and adjusted by the rudest hands."<sup>30</sup> This mode of marking would seem to have been standard practice, although where the building was particularly large and complicated a representative of the manufacturer was sent abroad to assist in the erection. (See Appendix II).

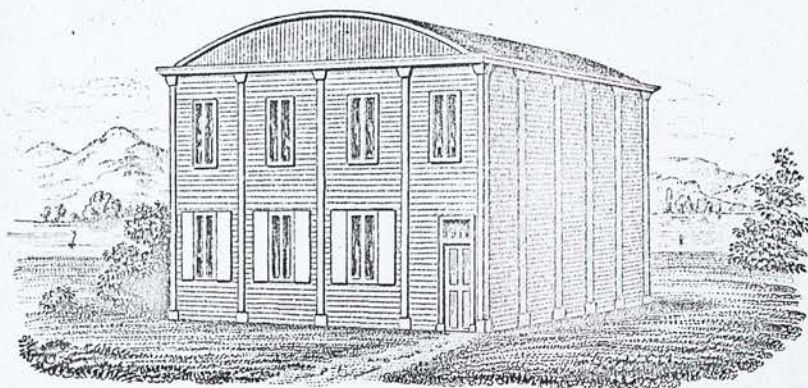
<sup>29</sup> The Illustrated London News, July 14th 1849, p. 20 shows an iron store house and dwelling for California by John Walker of London. See also the Builder, August 11th 1849, p. 382.

<sup>30</sup> Practical Mechanic's Journal, Vol. V, 1852-3, p. 274.

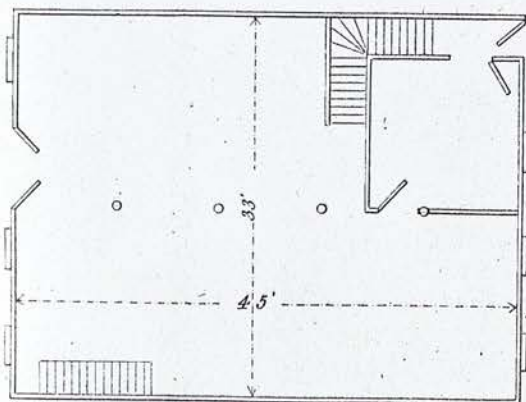
# IRON WAREHOUSE & DWELLING.

MESSRS EDW<sup>d</sup> T. BELLHOUSE & C<sup>o</sup> ENGINEERS,

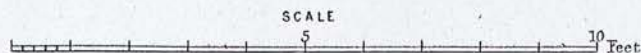
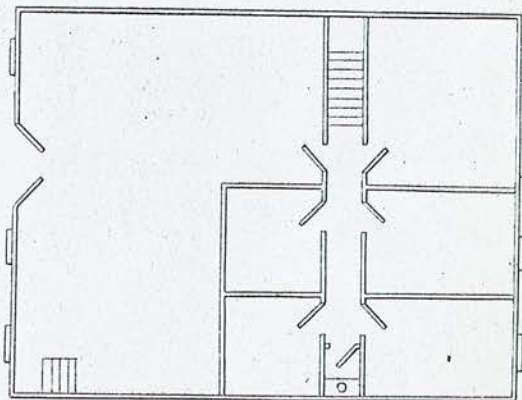
MANCHESTER.



Plan of Lower Floor



Plan of Upper Floor





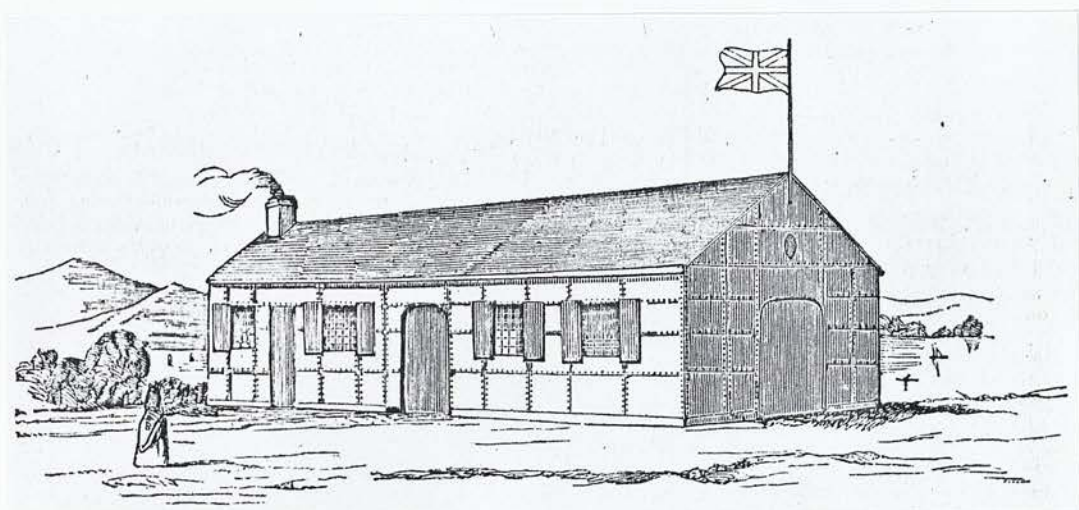


Plate 84. Iron warehouse, by E. T. Bellhouse, c. 1850.



A very similar story can be told of the Gold Rush in Australia in the early fifties.<sup>31</sup> Large numbers of similar portable corrugated iron houses were sent to Melbourne,<sup>32</sup> but a very important innovation in the export trade occurred in 1851. C. D. Young and Co. of Edinburgh<sup>33</sup> sent out to Melbourne a shop for Messrs. Miller and Dinsmoor of Collins Street,<sup>34</sup> the first 'handsome' cast iron building to be exported. The term 'handsome' was used to differentiate this kind of building from a corrugated iron building. Designs for 'handsome' buildings were generally prepared by architects<sup>35</sup> and the buildings were fabricated from heavy iron castings. Heavy castings were chosen because they

<sup>31</sup> McPhun's Australian News, and Record of Commercial Progress in Australia, published in Glasgow in 1853-4, gives a detailed account of the conditions at the diggings in Australia and devotes many articles to designs for portable iron houses for potential emigrants. Robert Walker's patented portable house for Australian emigrants is described in the Practical Mechanic's Journal, Vol. VI, 1853-4, pp. 162-3 (Patent No. 784, 19th November 1852).

<sup>32</sup> A surviving example of a group of corrugated iron houses in Patterson Street, South Melbourne is given in M. Casey, Early Melbourne Architecture 1840-1888, Melbourne, 1953, pp. 140-1.

<sup>33</sup> Charles Young, an Edinburgh ironmonger, is first recorded in 1842 marketing iron fencing. By the early 1850's he had a foundry in Perth and offices in Glasgow, Liverpool and London. He manufactured, at this time, a very large range of iron products - tools, machinery, bridges and buildings - particularly for the South American market. A large illustrated catalogue with text in Spanish and English was issued c. 1858. (Extensive searching has not unearthed a copy of this important catalogue).

<sup>34</sup> C. D. Young, Illustrations of Iron Structures, for Home and Abroad, manufactured by C. D. Young and Co., Edinburgh, n.d. (c. 1855), p. 4 and design No. 15, Plate IX.

<sup>35</sup> Young's designs were prepared by Messrs. Bell and Miller, Engineers and Architects.

afforded "greater scope for the display of architectural effect."<sup>36</sup>

"The most elaborate mouldings or the finest tracery work" could be executed with "more than ordinary durability and strength."<sup>37</sup>

The shop front of Miller and Dinsmoor (See Plate 85) was quite simply a stone front of classical design exactly reproduced in cast iron. The subject of the cast iron front is examined in detail in Chapter VII, but it is significant that it should have been deemed worthwhile to export (almost all cast iron fronts were made in the same city as they were erected in) such a heavy structure from Britain. The reason must surely have been a scarcity of skilled labour in Melbourne to produce an equivalent design in stone or stucco and perhaps, in addition it would have had the 'cachet' of a British product in a distant territory.

Young also used this 'handsome' cast iron work for houses. Plate 86 is a design for an iron cottage with a handsome cast iron front. It seems almost certain<sup>38</sup> that this was the design for the famous 'Villa Corio' at Geelong. (See Plates 87 and 88). If, however, we compare the plates, we notice that the villa as built differs in detail from the design. One bay has been transposed and one of the half-circular verandahs has been re-positioned. The

<sup>36</sup> C.D. Young, op.cit., p. 3.

<sup>37</sup> Ibid., p. 3.

<sup>38</sup> I drew Dr. Robertson's attention to this design when he visited this country in 1969. When he re-visited the villa in the following year he wrote expressing the view that it was without doubt the design that had been used.

IRON DWELLING HOUSE  
WITH SHOP BELOW.  
WITH HANDSOME CAST IRON FRONT

DESIGN Nº15

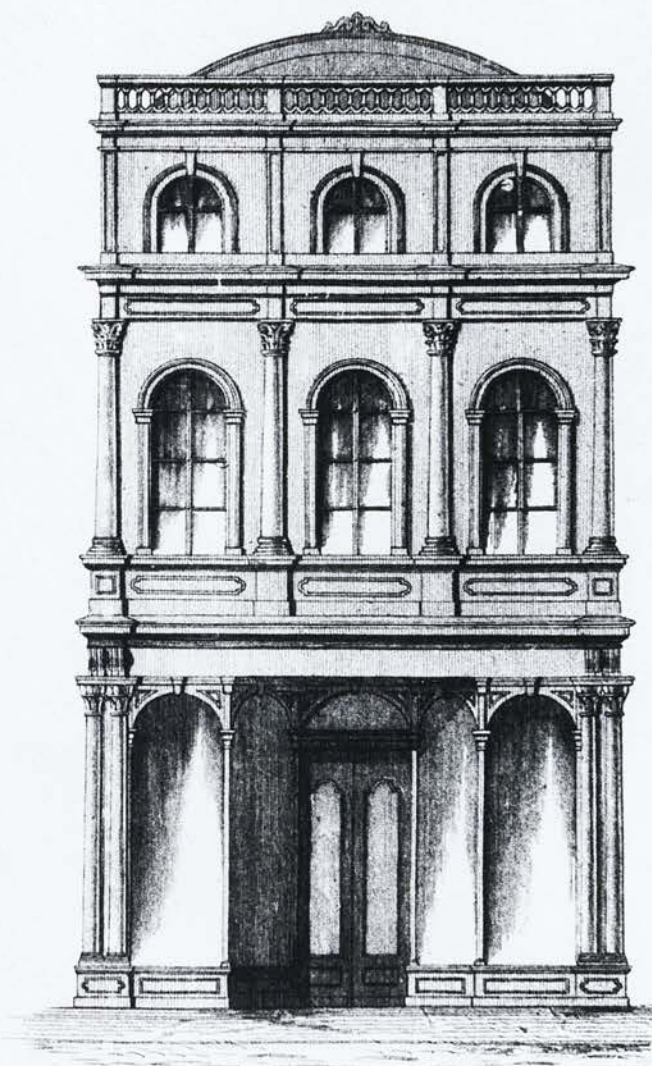


Plate 85. Messrs. Miller and Dinsmoor's Shop, Collins Street, Melbourne, by C.D. Young and Co., 1851.

IRON COTTAGE WITH HANDSOME CAST IRON FRONT.

DESIGN N°14

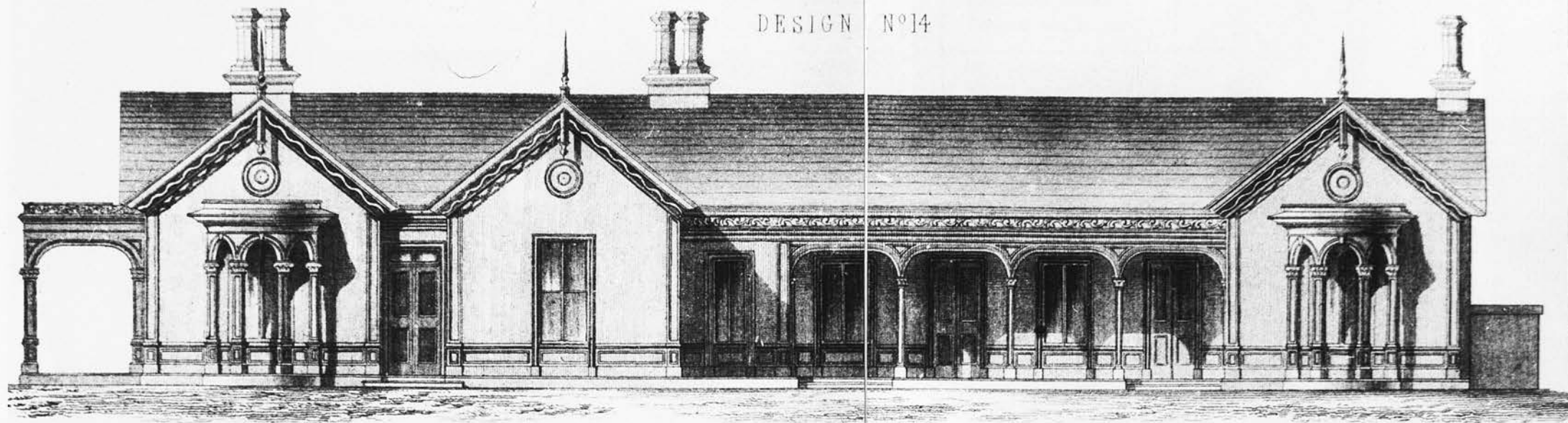
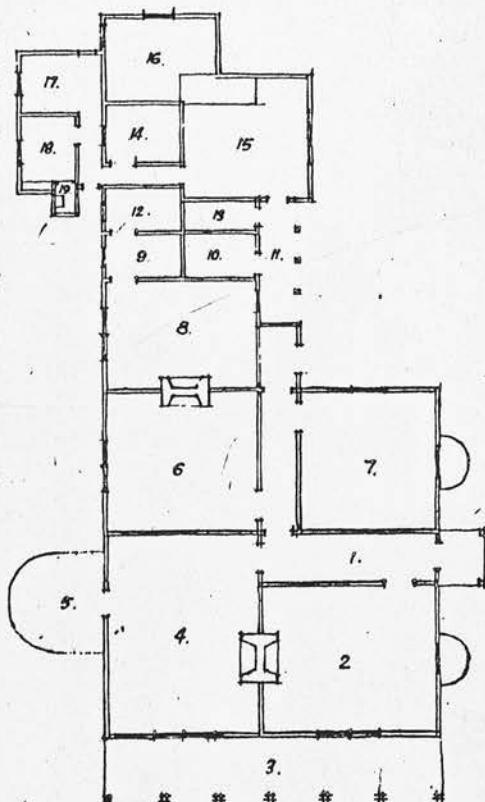


Plate 86. Iron cottage with handsome cast iron front, (Corio Villa),  
by C. D. Young and Co., c. 1854.





Plate 87. 'Corio Villa', Geelong, Australia, by C. D. Young and Co.  
1854.



Plan of Corio Villa in 1856,  
drawn by Mr. G. E. Drinnan.

LEGEND

1. Hall
2. Drawing Room, etc.
3. Verandah
4. Dining Room
5. Conservatory (since removed)
6. Bedroom
7. Bedroom
8. Bedroom
9. Dressing Room
10. Pantry
11. Verandah
12. Bathroom
13. Store
14. Maid's Bath and Store
15. Kitchen
16. Laundry
17. Scullery
18. Maid
19. W.C.

explanation for this intriguing discrepancy probably lies in the fact that Mr. Gray of the Colonial Land Commission, who originally ordered out the building from Britain,<sup>39</sup> never claimed it when it arrived in Geelong. It seems that it remained unclaimed for six months in the port before being sold to Mr. Alfred Douglass who had the structure erected by "certain ingenious colonial craftsmen . . . . . without plans or directions "<sup>40</sup> in 1855-6.

Most manufacturers had a number of standard designs which they marketed, but they were willing to produce a special design when the situation demanded it. A good example of this is E. T. Bellhouse's custom house and store for Payta, Peru of 1853-4. (See Plates 89 and 90). The commission was probably given to Mr. E. Woods,<sup>41</sup> a civil engineer, who then approached E. T. Bellhouse because of their experience of exported iron buildings. They in turn called in the Manchester architect, Edward Salomons<sup>42</sup> "who gave the aid of his talent in the design of the details and proportion."<sup>43</sup>

The constructional system of the custom house is similar to Porter's market house - an arrangement of cast iron pilasters on

<sup>39</sup> C.D. Young, op. cit., p. 4.

<sup>40</sup> E. Graeme Robertson, Victorian Heritage, Melbourne, 1960, p. 53.

<sup>41</sup> Woods, in association with the architects T.W. Goodman and C.H. Driver designed an iron market building for Santiago, Chile in 1869. (See Appendix I).

<sup>42</sup> Salomons also worked with C.D. Young and Co. on the Manchester Art Treasures Building in 1856-7. (See Appendix I).

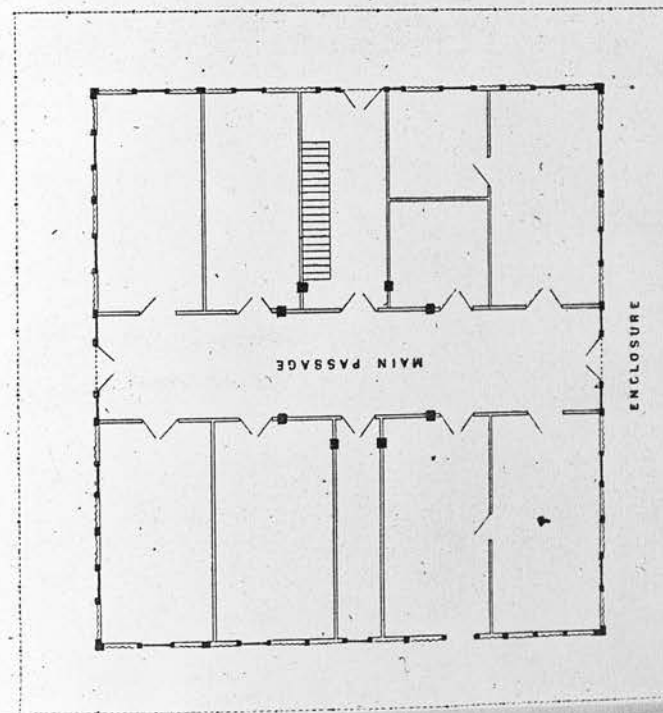
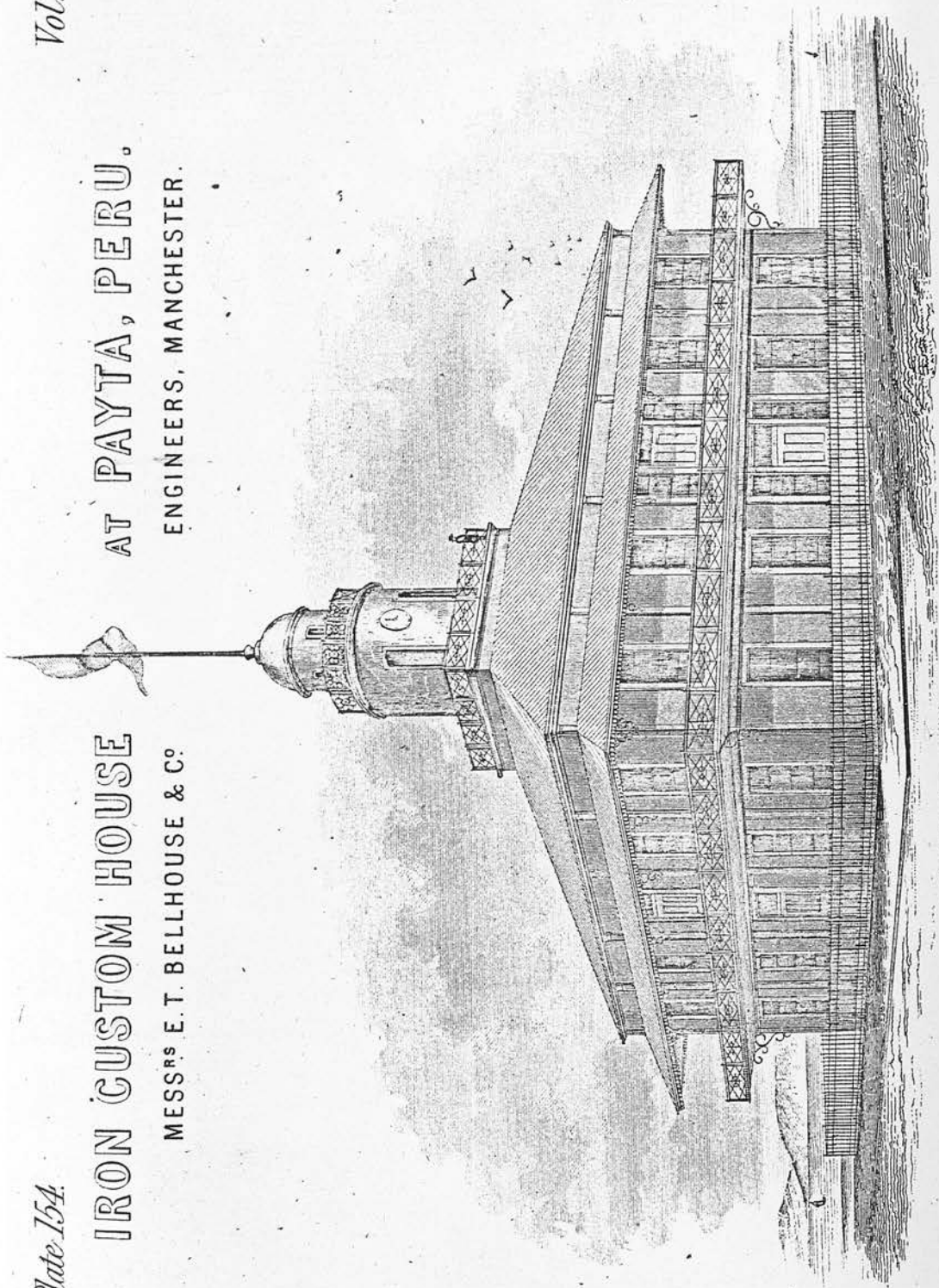
<sup>43</sup> Practical Mechanic's Journal, Vol. VII, 1854-5, p. 45.

# IRON CUSTOM HOUSE

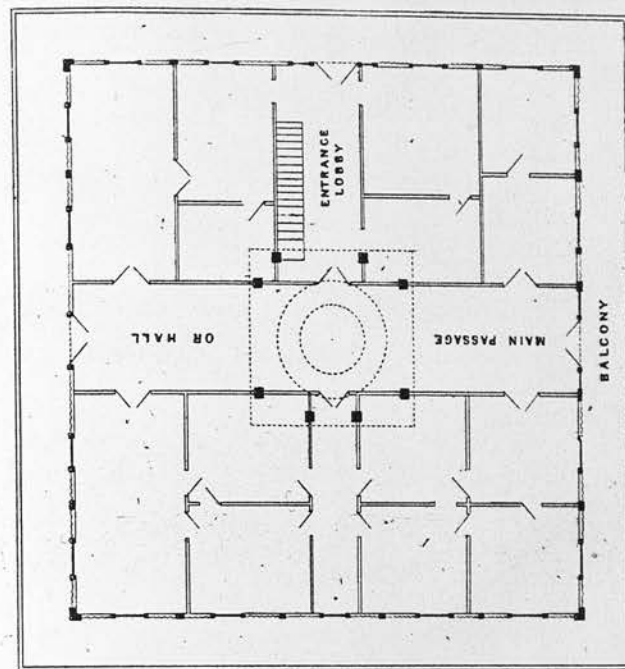
# AT PAYTA, PERU.

MESS<sup>RS</sup> E. T. BELLHOUSE & CO.

ENGINEERS, MANCHESTER.



GROUND FLOOR PLAN.



UPPER FLOOR PLAN.

W. Johnson, Patent Office,  
47 Lincoln's Inn Fields & Glasgow.

SCALE

0 5 10 20 30 40 50 60 70 FEET

G. Ashman del. & lith.

Plate 89. Custom house, Payta, Peru, by E. T. Bellhouse, 1853-4.  
Floor plans and perspective.



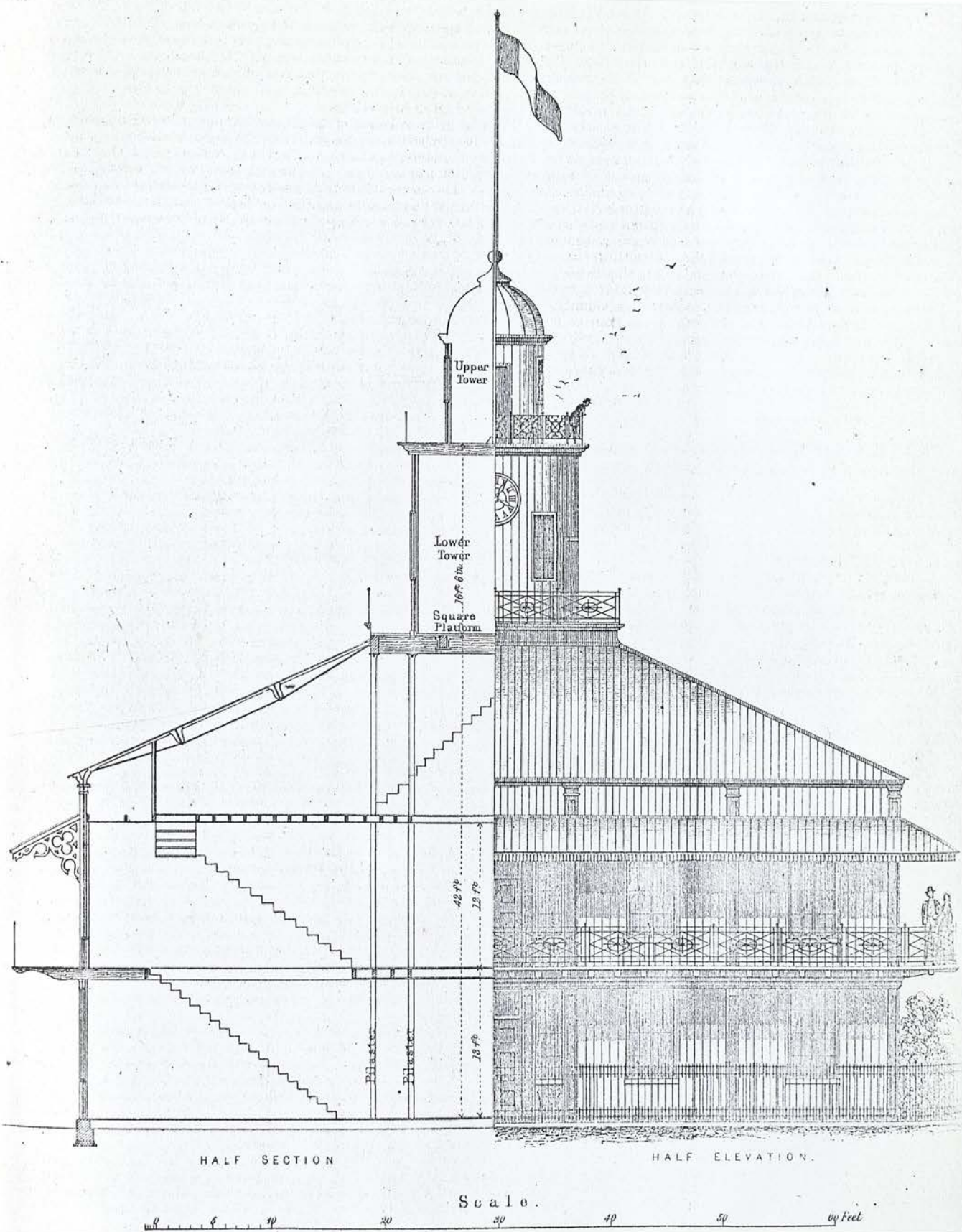


Plate 90. Custom house, Payta, Peru. Elevation.

a 7 feet bay system with infilling panels of corrugated iron. The roof structure was constructed of inclined trussed rafters with a covering of corrugated iron. Extensive use was made of timber in the design of the floor beams at first and second floor level, and in the circular clock tower. (See Plate 91, Figs. 3, 5 and 6). The general effect of this building is greatly enhanced by the details of the ironwork designed by Edward Salomons. As with the Kew Stove, the decorative details were used only at junctions and at those portions of the building where their absence would have made the building starkly plain.

Unfortunately this building has not survived<sup>44</sup> but the store (constructed on a similar system) still stands. This is a clear refutation that corrugated iron buildings could only be expected to last a short time.

Perhaps the most lavish of all the special designs for exported iron buildings was Robert Stephenson's<sup>45</sup> bathing kiosk for the Pasha of Egypt of 1858-60. (See Plate 92). Stephenson was given 'carte blanche' by the Sultan to design a building "fitted for all the comforts and luxuries peculiar to Imperial Oriental life, including baths, divans and other characteristic adjuncts."<sup>46</sup>

<sup>44</sup> During the War of the Pacific (the war between Chile and Peru - (1879-83) the Chileans dismantled the custom house and carried it off to Chile. After the war a replica in timber of the original building was built by the Peruvians and this still stands.

<sup>45</sup> Stephenson was a personal friend of the Pasha (Sa'eed Pasha - 4th son of the famous Mohammed 'Alee) and had been responsible for a considerable volume of public works in Egypt. See J. C. Jeaffreson, The Life of Robert Stephenson, 1864.

<sup>46</sup> The Building News, August 9th 1859, p. 708.

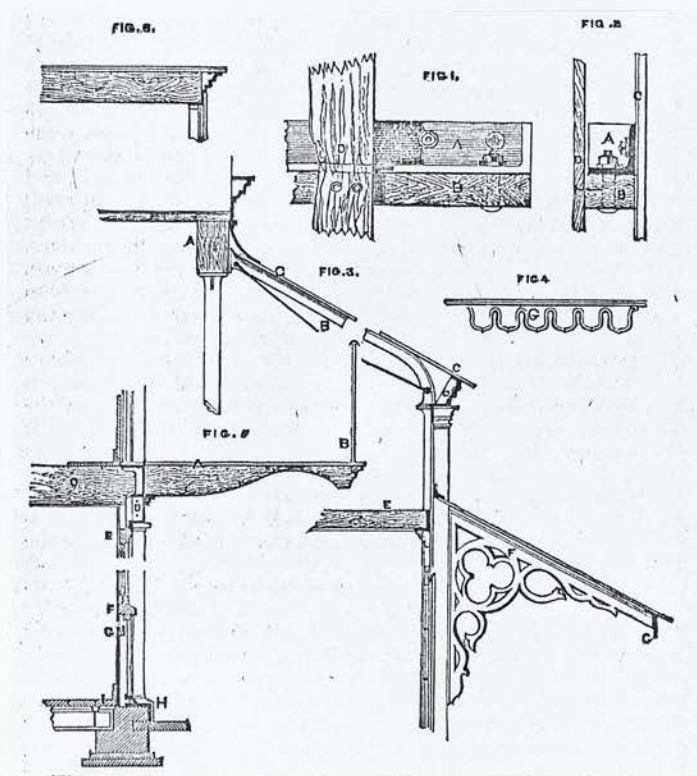


Plate 91. Custom house, Payta, Peru. Details.



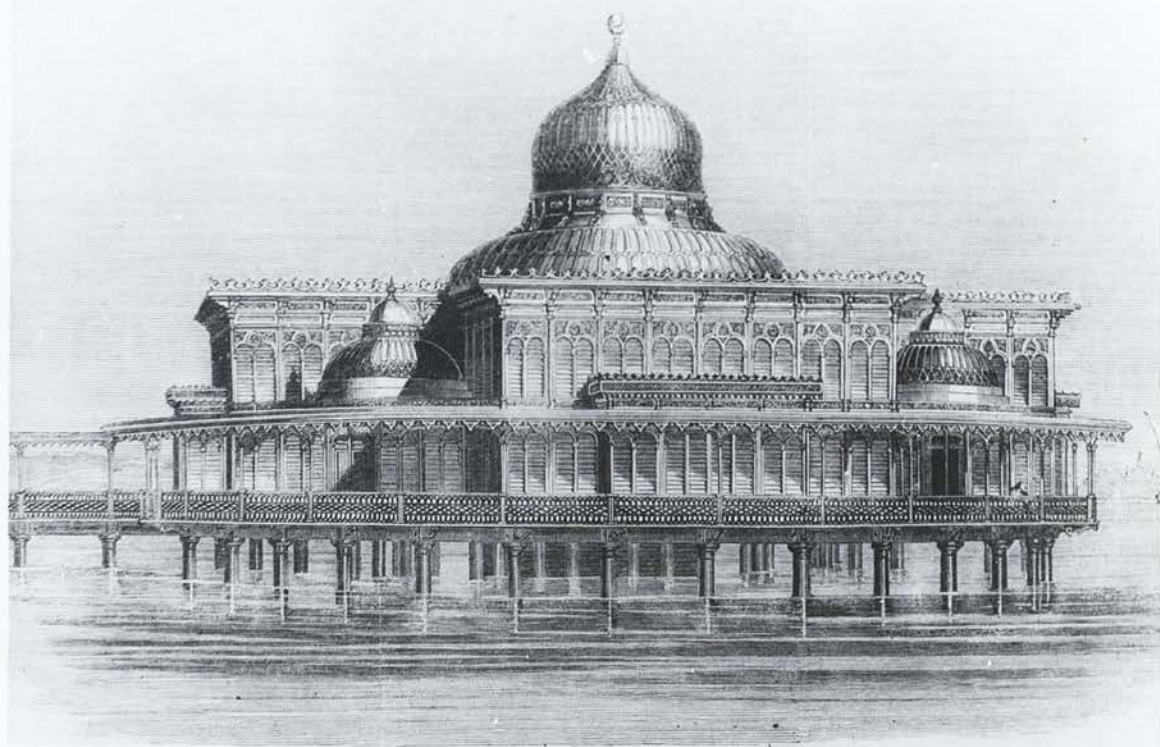


Plate 92. Kiosk for the Pasha of Egypt, Kafrellais, by Robert Stephenson, 1858-60.



The design displayed great opulence and the style was "as near an approach as possible to the Saracenic - that is as near as the materials will admit of."<sup>47</sup>

The plan was in the form of a 'Greek cross' with a lofty central dome with four smaller domes surrounding it. The whole iron construction<sup>48</sup> stood on a vast circular platform of 120 feet diameter, which was supported over the water<sup>49</sup> by a grid of sixty iron columns.

Beneath the central dome the bath was suspended by a richly ornamented chain with winding gear to enable the bath to be adjusted to the level of the Nile. The interior was richly ornamented with coloured glass in the domes and much of the iron work was either painted in rich colours or bronzed. The floors were of "best English encaustic tiles"<sup>50</sup> in elaborate designs.

The general effect must have been quite splendid. "If we conceive the brilliancy of an Eastern sun, and the clearness of an Eastern atmosphere, we may imagine the effect of this kiosk glittering with its reflection in the waters of the most classical river in the world."<sup>51</sup>

This design has many similarities to Andrew Handyside's kiosk

<sup>47</sup> Illustrated London News, October 30th 1858, p. 405.

<sup>48</sup> The ironwork was supplied by H. and D. Grissell of London.

<sup>49</sup> The kiosk was erected at Kafrellais on the Nile (now called Hamam El Basha).

<sup>50</sup> Illustrated London News, October 30th 1858, p. 405.

<sup>51</sup> Ibid., p. 405.

for Bombay. (See Appendix II, Figs. 5 and 6). The responsibility for the design was in the hands of an engineer working closely with the ironfounders and, in the case of the Bombay building, an architect (Owen Jones) to advise on the 'architectural effects.'

Handyside's work provides a particularly interesting example of an ironfounder and manufacturer of iron buildings whose work extended from the simplest iron house to the most splendidly ornamental structures,<sup>52</sup> and where their manner of designing and manufacturing is able to be unravelled.

Their published catalogue contained an extensive range of designs for iron components which could be easily assembled. Dimensions were standardized and the jointing methods were simplified to give a high degree of interchangeability. Stocks were not held of these components but the wooden patterns were available so that as soon as an order was received casting could begin. Much of their work could simply be constructed from standard catalogue items but should the design be complicated, special patterns would be made for the castings. For such a building they usually engaged an engineer<sup>53</sup> to work out the special details and take responsibility for the stability and strength of the structure.

Between 1860 and 1880 the bulk of the trade in exported iron buildings would seem to have been in the hands of two firms.

<sup>52</sup> For a detailed account of their work see Appendix II.

<sup>53</sup> R. M. Ordish, a Derby engineer was employed on many of Handyside's buildings.

Handyside's principally operated in India, Young's in South America. In spite of these firms domination of the market, Laidlaw and Sons' market for Santiago of 1869 is a highly successful decorative building of this period. (See Plate 93). Handyside's rival in Derby, James Haywood, also sent out to Bombay in the same year a gigantic iron building known as Watson's Building. (See Plates 94 and 95). The designer was R.M. Ordish, acting as both engineer and architect, who achieved a quite remarkable richness in the cast iron details. (See Plate 96).

As we move into the 1870's the export of decorative or 'handsome' buildings fell into decline. As the colonial territories became able to produce their own ironwork<sup>54</sup> it became less and less economical to export these buildings. But of even more importance, as first wrought iron and subsequently steel, came into common use they were employed simply for their structural advantages and the decorative elements in the buildings were provided by the use of traditional materials - brick, stone, stucco and tilework.

In spite of this, the trade in very modest corrugated iron buildings continued. Even in 1910 a manufacturer (W. Cooper of London)<sup>55</sup> was still offering iron buildings suitable for the Colonies, South Africa and India. Plate 97 shows their standard church, a design unpleasantly reminiscent of the 'coke sheds' of the 1840's.

<sup>54</sup> Australia provides a particularly vivid instance of this development. See E. Graeme Robertson, Ornamental Cast Iron In Melbourne, Melbourne, 1967.

<sup>55</sup> William Cooper Ltd., Illustrated Catalogue of Conservatories, Greenhouses, Portable Wooden Buildings, Incubators, Rustic Work, Iron Buildings, etc., (1910).

SANTIAGO MARKET.

Scale of Feet



SECTION THROUGH SIDE ROOFS  
AND ANGLE PAVILIONS.

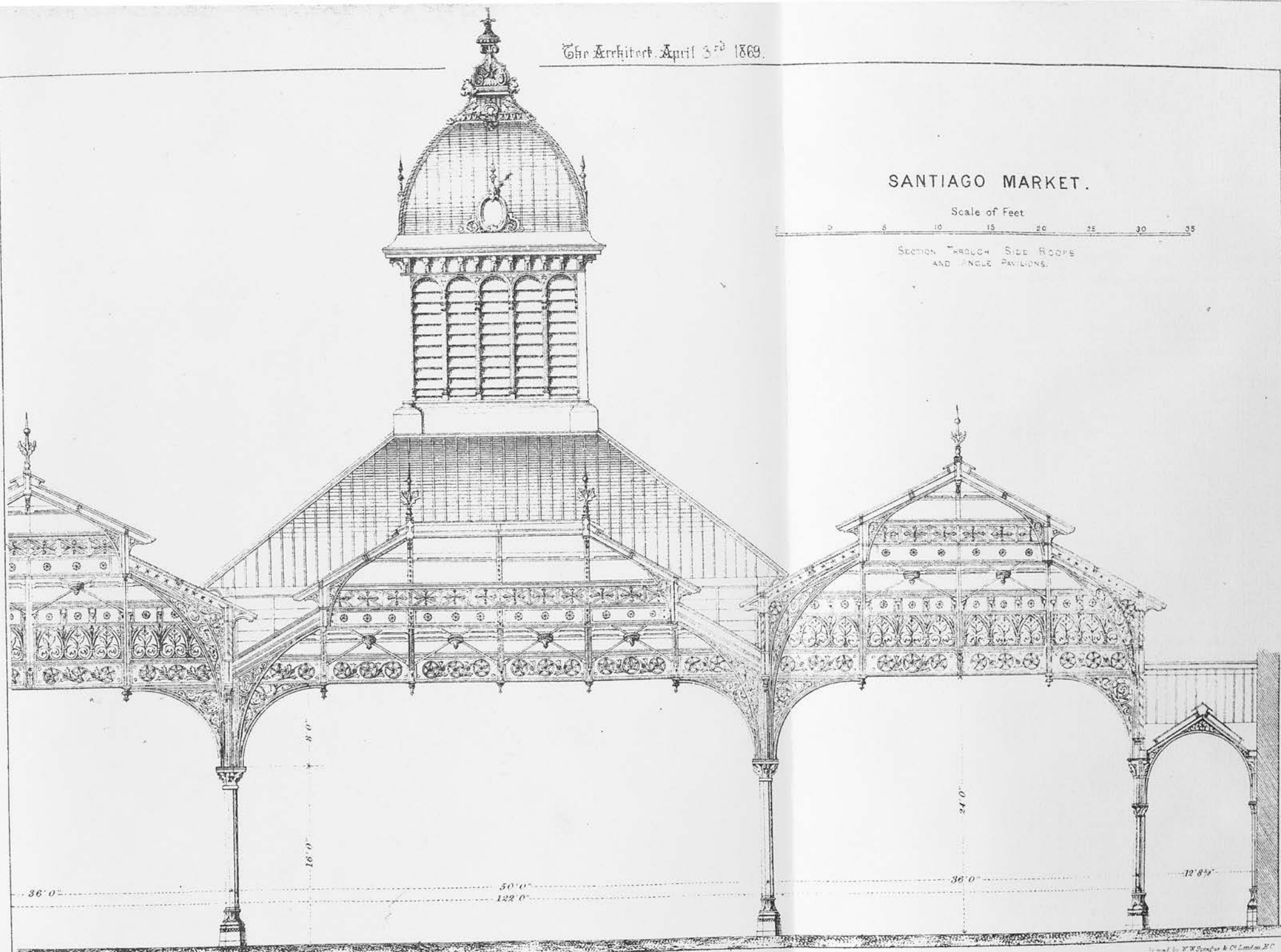


Plate 93. Market at Santiago, Chile, by C. H. Driver and T. W. Goodman, 1869. Cross section.



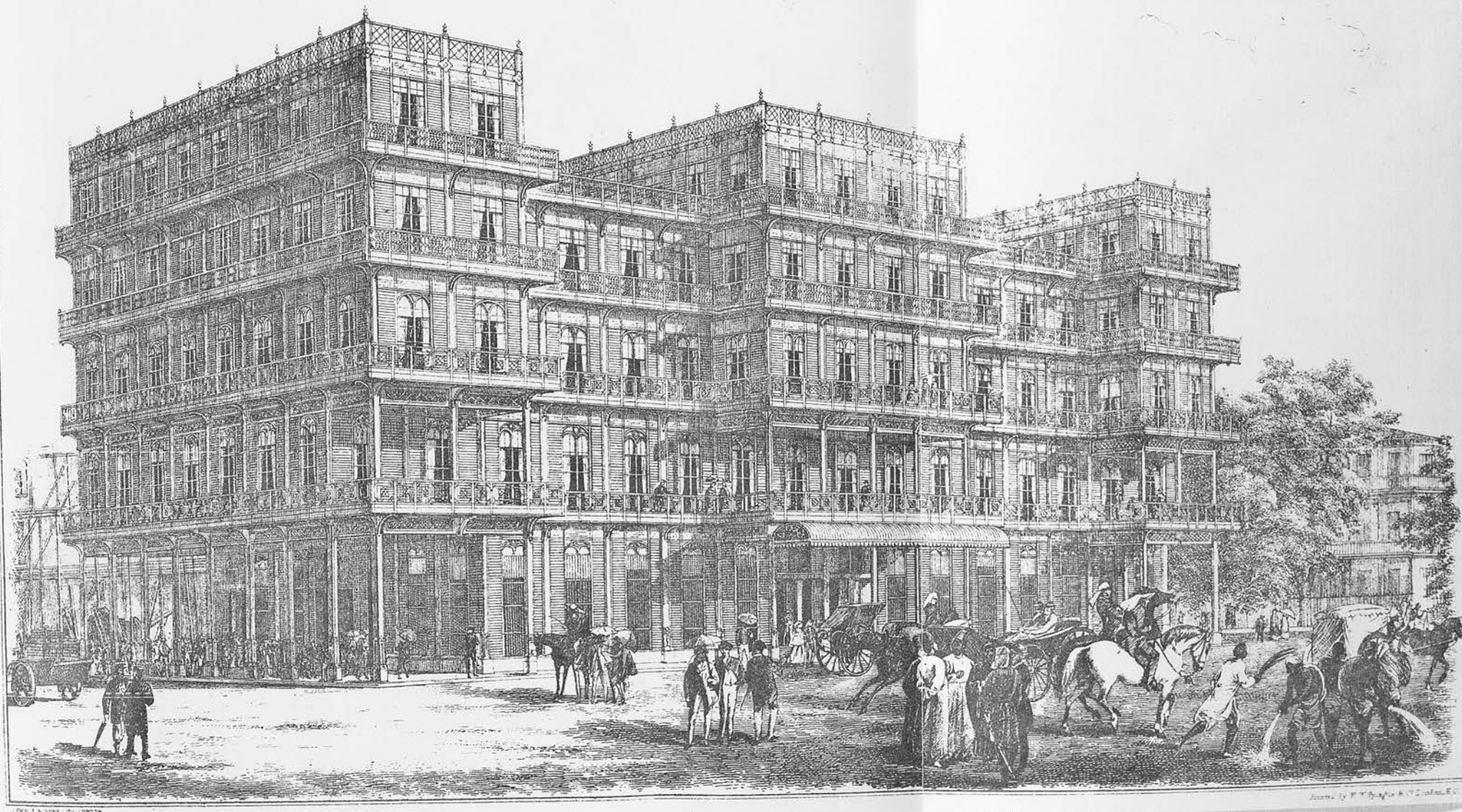


Plate 94. Watson's Building, Bombay, by R.M. Ordish, 1869.



Plate 95. Watson's Building, Bombay.



Fig. 1.

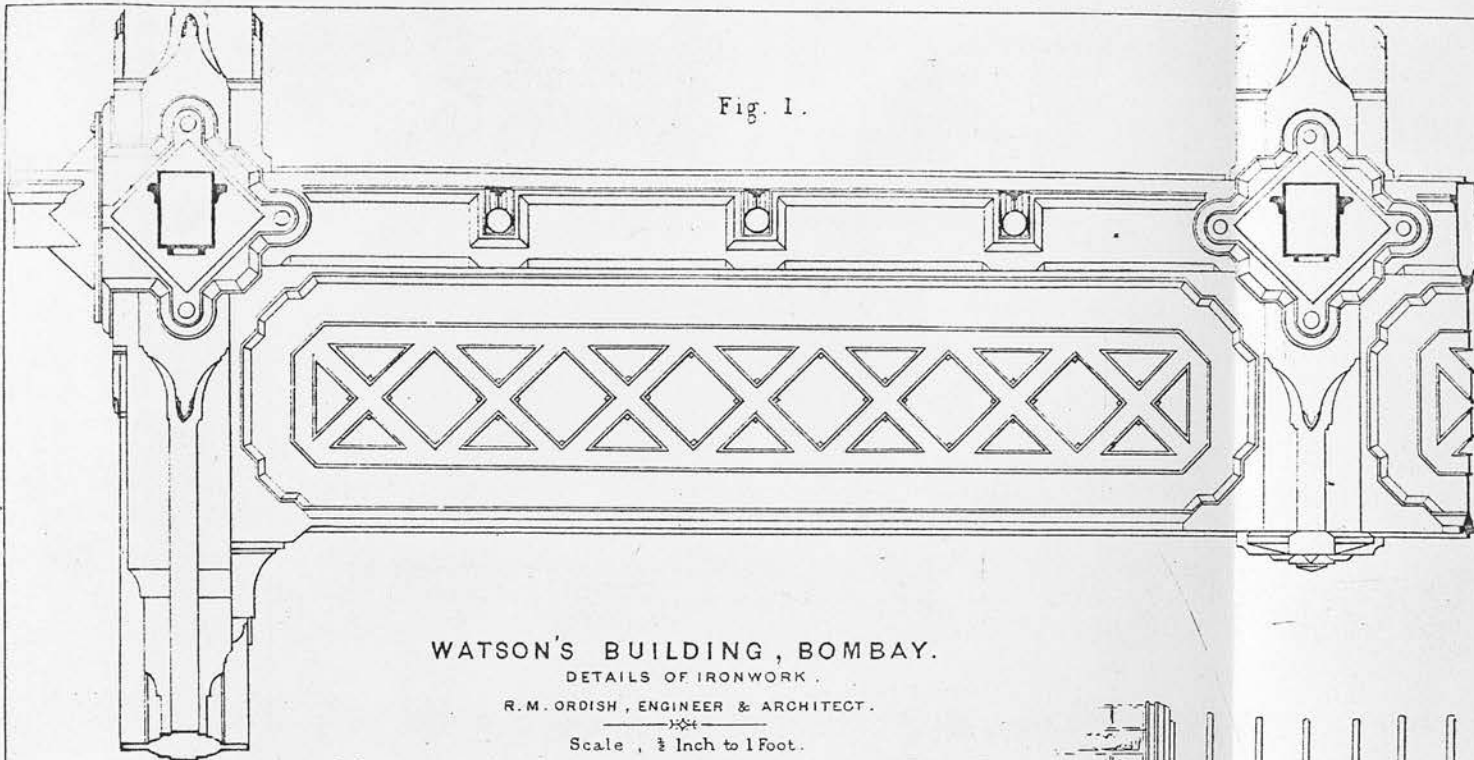
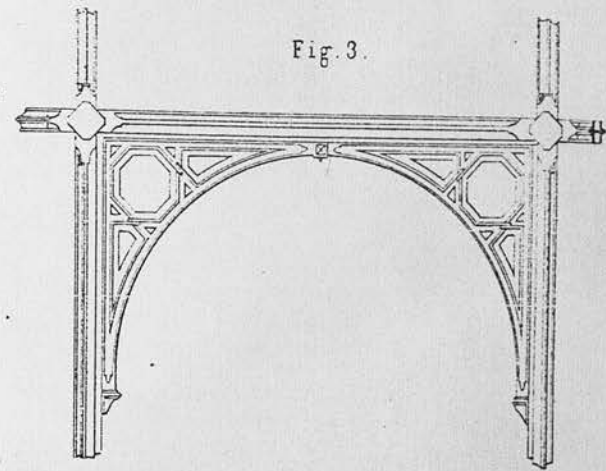


Fig. 3.



WATSON'S BUILDING, BOMBAY.

DETAILS OF IRONWORK.

R. M. ORDISH, ENGINEER & ARCHITECT.

Scale,  $\frac{1}{2}$  Inch to 1 Foot.

Inches 12 9 6 3 0 1 2 3 4 5 Feet

Fig. 2.

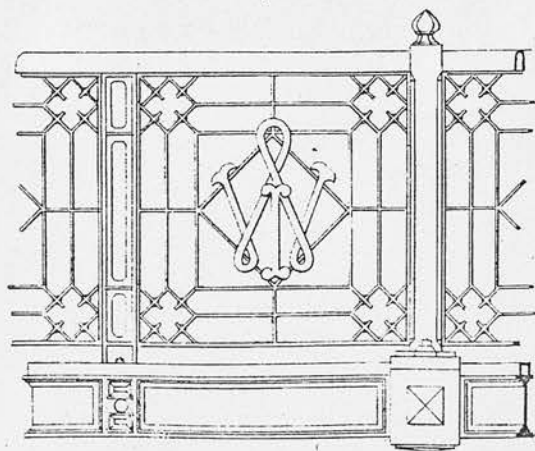
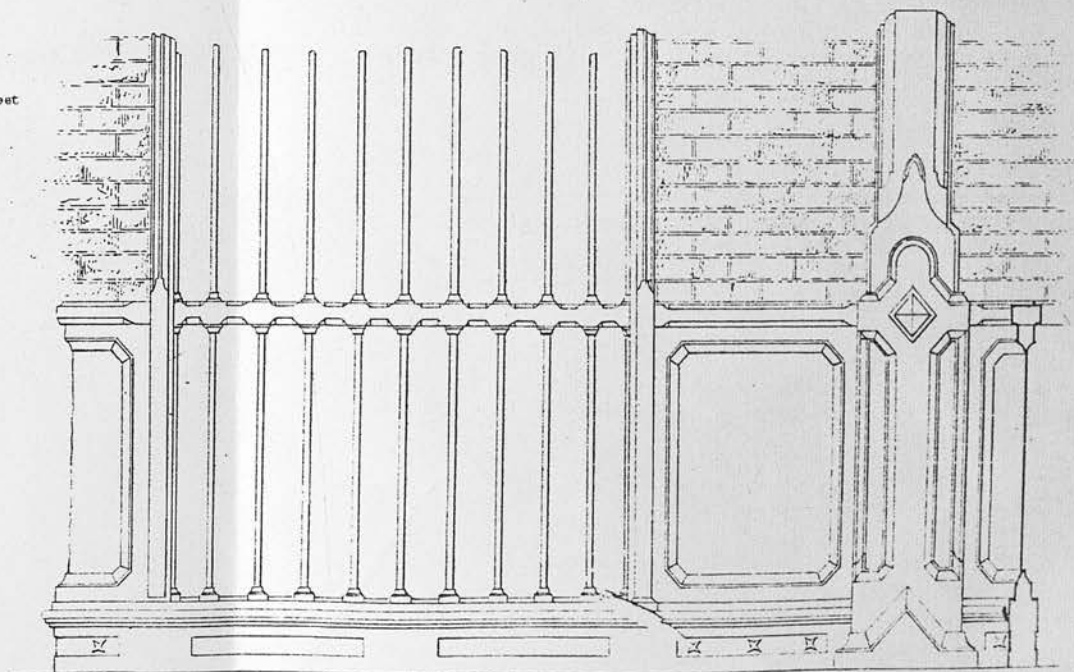


Fig. 4.



J. ENSLEY & SONS, LTD., LONDON

Buildings is even damp, hence the readiness with which medical authorities resort to them for hospitals in cases of emergency. For those who take their pleasures up-river year by year, a portable building affords a means of enjoyment and change upon a scale of economy not found in any other system. We contract for every interior requisite, heating, lighting, cooking apparatus, furniture, &c., &c., whether required for the Church or the Gamekeeper's Cot.

## EXPORT TRADE.—Buildings suitable for all Climates— The Colonies, South Africa, and India.

Great care is necessary, not only in the construction, but in the selection of materials for all Buildings required for use in foreign countries. The experience we have had in this department, combined with assistance rendered to us by old residents abroad, has enabled us to turn out work which has met the full appreciation of those for whom we have contracted.

### For Tropical Climes

our Buildings are constructed with a double roof, each end being covered with perforated zinc in order to admit a through current of air. This not only assists to cool the interior, but may be made to act as a thorough ventilator.

**Our Buildings are all made in Sections,** and tested as a whole, before leaving our Works. Each part is numbered and lettered to correspond with a diagram which accompanies the Building, so that reference is made easy, and the putting together of the sections is a matter of common intelligence, no technical skill being required.

### Packing for Shipment

has the greatest attention, so that the parts may be protected from rough usage, consequent upon a long voyage and transshipments and carriage overland.

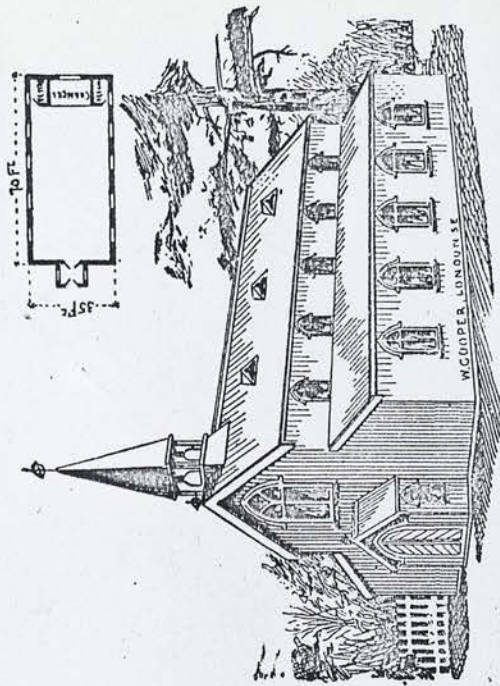
### Portable and Tenants' Fixtures.

Being portable and tenants' fixtures, these Buildings commend themselves for service in all parts of the world. They can be enlarged or made small with comparative ease in any case of emergency.

If designs in this list do not meet with purchasers' requirements, Special Designs and Estimates will be promptly despatched on receipt of Rough Sketch and Particulars.

**Special Designs Free.**

## Church.



No. 276.

This Church is handsomely designed, and can be constructed to suit any number of people. Lowest cash estimates given for other sizes on receipt of particulars. Furniture, Lighting, and Heating Apparatus separately estimated for. For Specification, see pages 206 and 207.

Delivered nearest Goods Station, and erected complete on purchaser's foundation, or marked for re-erection, and bundled and packed on Rail or Wharf.

### PRICES :

60ft. long by 30ft. wide, 9ft. to eaves, 26ft. to ridge,  
Erected complete, £300.

On Rail or Wharf, £200.

70ft. long by 40ft. wide, 9ft. to eaves, 30ft. to ridge,  
Erected complete, £415.

On Rail or Wharf, £275.

Exclusive of fittings.



The cast iron front was an American invention. It was not simply a means of providing an additional source of income for a characteristic type of commercial building but responded to the rapidly expanding cities of the East coast of America in the second half of the 19th century.

The centre of this trade was New York and between the mid 40s and the first years of the century<sup>2</sup> a very large number of these fronts were erected, many of which survive to this day.<sup>3</sup>

It is unnecessary to repeat here the story of the development of this trade which has been so ably researched by Banister and

## CHAPTER VII

### Cast iron fronts in Britain and America (1829-80).

<sup>1</sup> When making a street by street survey of iron fronts in New York in 1965, in many cases it was only possible to distinguish iron fronts from stone by using a magnet.

<sup>2</sup> Although until recently, it was popularly believed that the iron front declined in popularity in the 70's, Carvin Robinson has shown that the trade flourished until at least 1912. See, *Late Cast Iron in New York*, *Journal of the Society of Architectural Historians*, May 1971, pp. 164-5.

<sup>3</sup> The area of cast iron fronts centred on Broadway, south of Washington Square, extending several blocks to East and West and continuing right down to the Financial District.

\* One firm (The Architectural Ironworks of New York) had built at least 125 iron fronts on Broadway by 1865.

<sup>4</sup> Tappin Banister, *Regarding Revivals*, Part I - *The Iron Front*, *Journal of the Society of Architectural Historians*, December 1959, pp. 12-22. Walter Knight Burgess, *Cast Iron in New York*, *Architectural Review*, October 1951, pp. 124-5.

The cast iron front was an American invention. It was quite simply a means of providing an imitation stone facade in cast iron<sup>1</sup> for a characteristic type of commercial building that flourished in the rapidly expanding cities of the East coast of America in the second half of the 19th century.

The centre of this trade was New York and between the mid 40s and the first years of this century<sup>2</sup> a very large number of these fronts were erected, many of which survive to this day.<sup>3</sup>

It is unnecessary to repeat here the story of the development of this trade which has been so ably researched by Bannister and Struges.<sup>4</sup> However these studies do not discuss a number of important ideas embodied in the design and manufacture of iron fronts. These omissions concern both technical and artistic ideas.

1 When making a street by street survey of iron fronts in New York in 1966, in many cases it was only possible to distinguish iron fronts from stone by using a magnet.

<sup>2</sup> Although, until recently, it was popularly believed that the iron front declined in popularity in the 70's, Cervin Robinson has shown that the trade flourished until at least 1910. See, Late Cast Iron in New York, Journal of the Society of Architectural Historians, May 1971, pp. 164-9.

3 The area of cast iron fronts centres on Broadway\* south of Washington Square, extending several blocks to East and West and continuing right down to the Financial District.

\* One firm (The Architectural Ironworks of New York) had built no less than 133 iron fronts on Broadway by 1865.

4 Turpin Bannister, Bogardus Revisited, Part I - The Iron Fronts, Journal of the Society of Architectural Historians, December 1956, pp. 12-22. Walter Knight Sturges, Cast Iron in New York. Architectural Review, October 1953, pp. 232-7.

Although the trade in iron fronts was on a very large scale<sup>5</sup> two men seem to have been responsible for the major developments in this trade. They were James Bogardus<sup>6</sup> and Daniel Badger.<sup>7</sup>

Bogardus published a most important pamphlet in 1856<sup>8</sup> in which he gives a most masterly exposition of the principles of building in iron.

His first ideas on iron buildings were crystalized on a tour of Italy in 1840<sup>9</sup> when he was "contemplating the rich architectural designs of antiquity" and "first conceived the idea of emulating them in modern times by the aid of cast iron."<sup>10</sup> Although Bogardus suggested that "every style of architecture and every design the artist can conceive, however plain or however complicated can be executed exactly in cast iron",<sup>11</sup> he thought that the material could

<sup>5</sup> M. Higgs, Iron men, R.I.B.A. Journal, January 1971, p.39.

<sup>6</sup> For a brief biographical account see, Sigfried Gideon, Space, Time and Architecture, 4th edition, 1963., pp.193-8.

<sup>7</sup> Born in New Hampshire 1806. Established an iron foundry in Boston in 1829. Moved to New York in 1846 and founded the Architectural Iron Works of New York.

<sup>8</sup> James Bogardus, Cast Iron Buildings, their Construction and Advantages, New York, 1856. Although the title page bears his name, the writer of the pamphlet was John W. Thomson. Some doubt exists therefore as to the originator of the ideas contained in the pamphlet.

<sup>9</sup> In the same year he visited London and could have seen Fairbairn's Corn Mill in the Works at Millwall before its dispatch to Turkey.

<sup>10</sup> James Bogardus, op. cit., p. 4.

<sup>11</sup> Ibid., p.14.

furnish us with a new style of architecture. Because of its greater strength cast iron would necessitate a new system "of proportional fitness of parts"<sup>12</sup> which would open "a wide field for new orders of architecture."<sup>13</sup>

In spite of the magnitude of the trade in iron fronts in New York no such style emerged. Paradoxically the most original designs were produced by Bogardus at the beginning of his career in 1848.<sup>14</sup> (See Plate 98). All his later fronts, as with the other New York firms, were heavily ornamented in imitation of stone. (See Plate 99). They received harsh criticism at the time. "The pretensions and vulgarity of these over-ornamented fronts, in due time, brought them into well merited contempt, and sealed their condemnation by every person who had any knowledge at all of what is truthful and comely in architecture."<sup>15</sup> Iron "wants proper treatment, and asks not to be set up as a false jewel, coloured and sanded in imitation of stone, or made flashy with over-ornamentation."<sup>16</sup>

<sup>12</sup> Repton expressed the same idea when describing the Plas-Newydd conservatory. See Chapter III, p. 35.

<sup>13</sup> James Bogardus, op. cit., p. 14.

<sup>14</sup> Bogardus' factory, Centre and Duane Streets, New York, 1848: Laing Stores, Washington and Murray Streets, New York, 1849.

<sup>15</sup> William J. Fryer, Iron Store Fronts, The Architectural Review and American Builders' Journal, April 1869, p. 620.

<sup>16</sup> Ibid., p. 621.



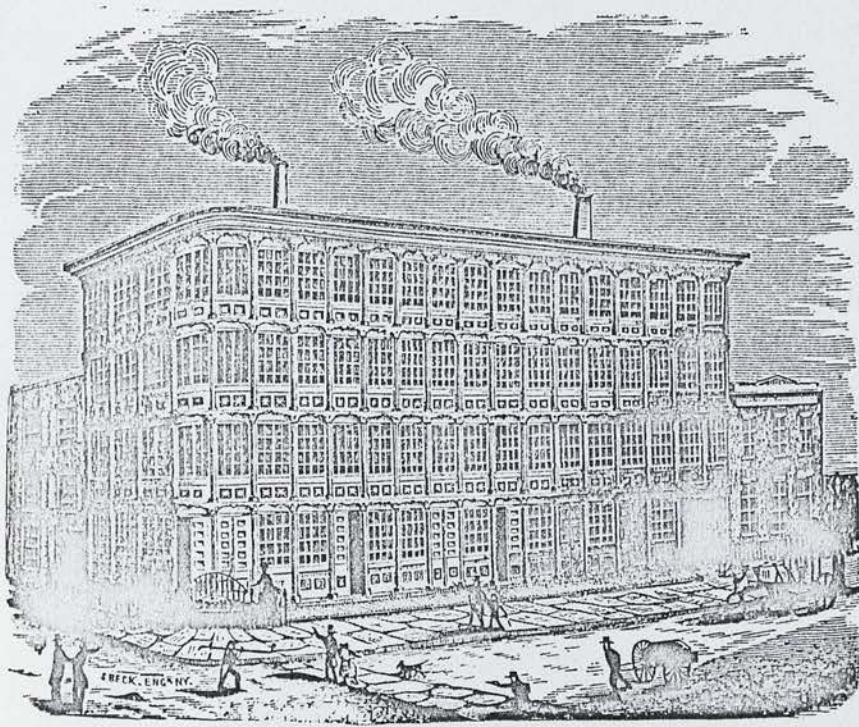


Plate 98. Cast iron factory, New York, by James Bogardus, 1848-9.

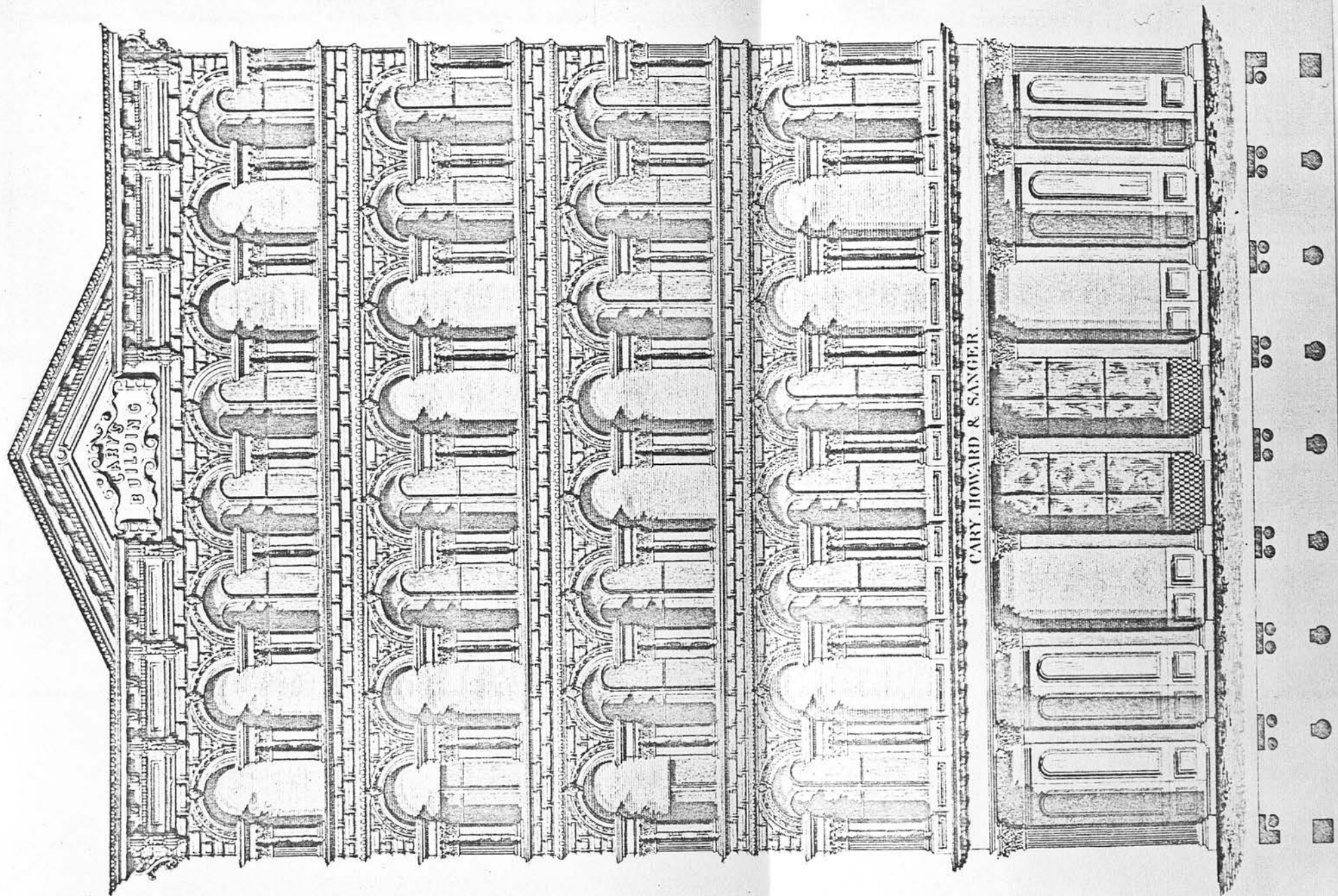


Plate 99. Cary Building, Chambers Street, New York, by Daniel Badger, before 1865.



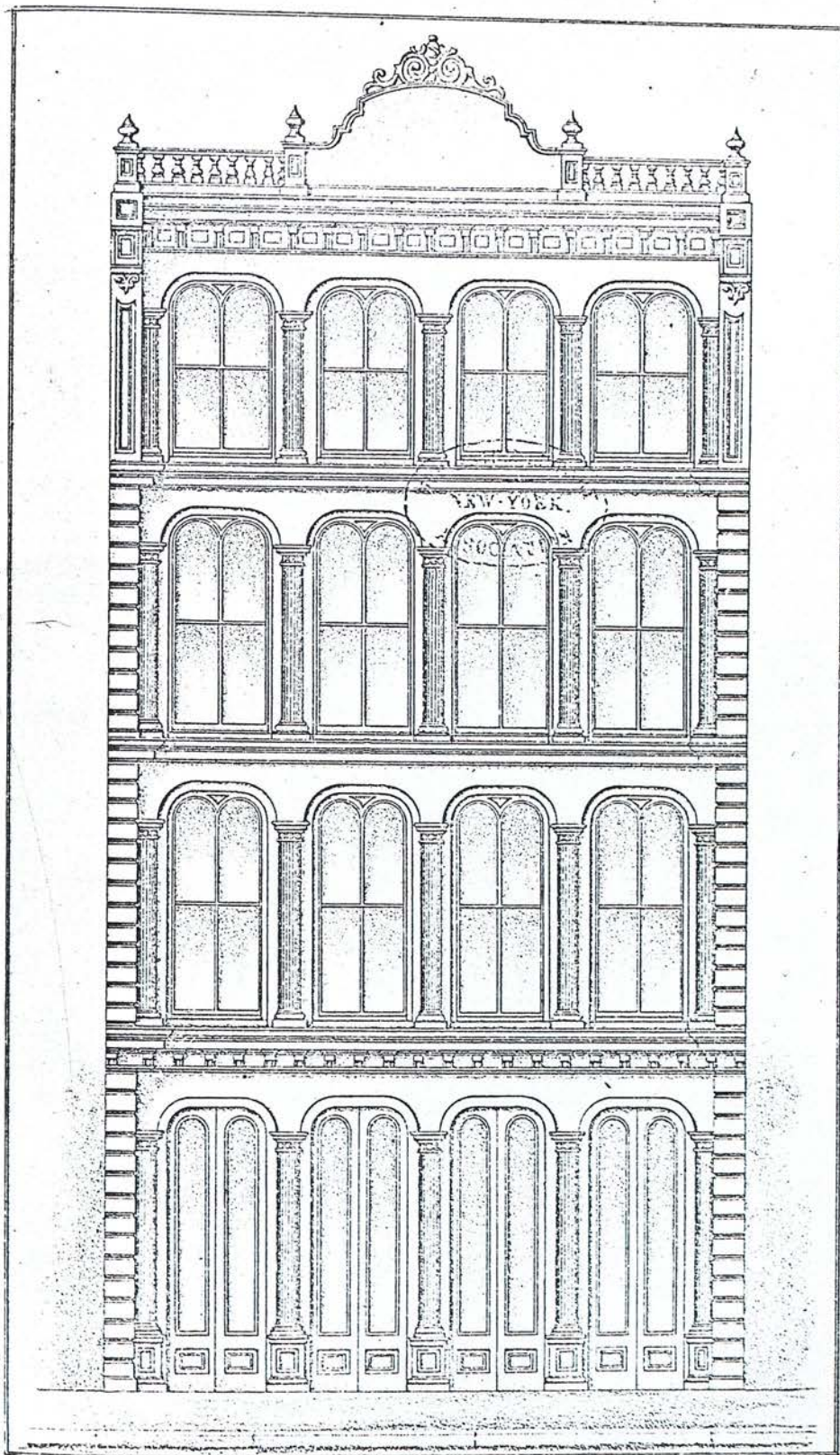
As an attempt to correct this misuse of the material the author of these comments (William Fryer) published a set of seven designs for iron fronts.<sup>17</sup> Plates 100 and 101 are two examples from this set. The designs can hardly be said to represent an alternative to the current examples of over-ornamented fronts. However certain architectural subtleties do appear in the designs. The floor heights diminish towards the top of the facade in both designs and in the first the system of flat arches described by a flat continuous plate is certainly a feature that would be unlikely to occur in a stone building. However he was still content to use a fluted Corinthian column as the main motif of the second design with all its attendant intricacies and consequent difficulties in casting.<sup>18</sup>

The main body of Bogardus' pamphlet was concerned with important technical principles. When he described the erection of his own cast iron factory (See Plate 98) he explained how each floor was assembled by bolting together the cills, columns and fascias. When this was rigid the next floor was added and this process continued "for any required number of stories."<sup>19</sup> Although not

<sup>17</sup> Published in the Architectural Review and American Builders' Journal, April, May, June, July and August 1869, February and March, 1870.

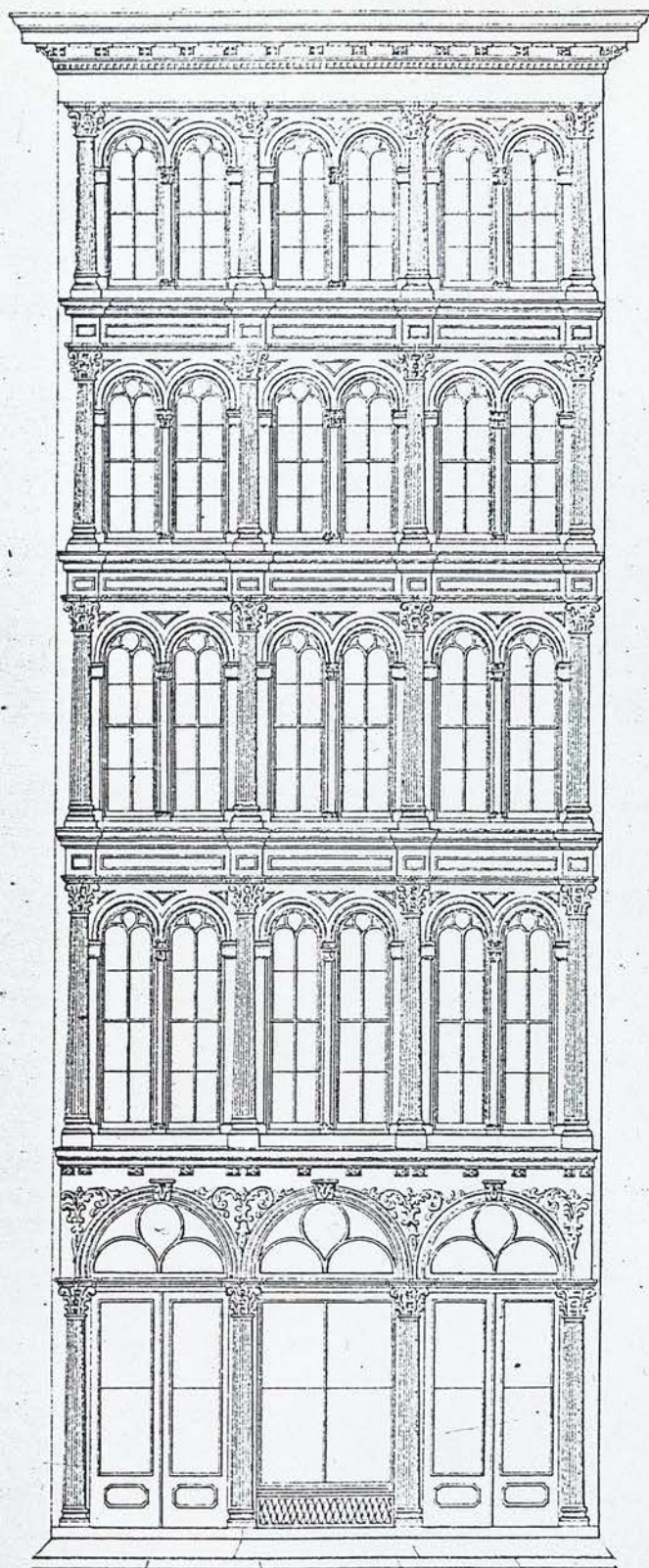
<sup>18</sup> Because of the undercutting in the Corinthian capital it was common practice to cast the acanthus leaves separately and then tap screw them to the body of the column. Similar techniques were used for the foliated scrolls in cornices.

<sup>19</sup> James Bogardus, op. cit., p. 6.



IRON STORE FRONT.





IRON STORE FRONT .

emphasized by Bogardus this statement contains the germ of the idea for a multi-storey iron framed building,<sup>20</sup> which was to be realised later, in such a spectacular way, in Chicago after the Great Fire of 1871.<sup>21</sup>

Bogardus' second important principle is central to the economic arguments for prefabricating buildings. Because an iron building was fabricated inside a factory the time spent on site was reduced to a minimum, and, as the assembly relied on bolted joints, the building could be "erected with extraordinary facility and at all seasons of the year."<sup>22</sup>

The last principle concerns portability. Bogardus explains how "the size and form of the pieces" of the building have been adjusted to "greatly favor their portability".<sup>23</sup> Although not a new idea<sup>24</sup> it was the first time that it had been explicitly stated in relation to buildings.

<sup>20</sup> The same idea is expressed in Viollet-le-Duc, Entretiens sur l'architecture, Tome II, 1872, p. 133. "On conçoit qu'un architecte, familier avec les moyens pratiques de l'art, ait l'idée d'élever un vaste édifice, dont l'ossature soit entièrement en fer."

<sup>21</sup> The best account of the evolution of the skyscraper is given in Carl W. Condit, The Chicago School of Architecture, Chicago, 1964.

<sup>22</sup> James Bogardus, op. cit. p. 7

<sup>23</sup> Ibid, p. 7

<sup>24</sup> This idea first appears in Thomas Paine's patent for bridges. See Chapter I, p.11.

Daniel Badger was much less of a theorist than Bogardus. His book<sup>25</sup> was, in his own words "published . . . for the . . . purpose of supplying Architects and others with plans and details for the construction of the various parts and connections of Architectural Iron Structures" and it was also designed "as an advertising medium for the Architectural Iron Works."<sup>26</sup> The book is most handsomely illustrated with an astonishing variety of designs which gives some hint of the enormous size of his business.<sup>27</sup> (See Plates 102-5)

There is a short introduction in which he lists strength, lightness, ease of erection, economy, durability and incombustibility<sup>28</sup> as the main advantages of iron fronts. In addition he offers the familiar argument that it is possible to reproduce in iron the architectural forms of wood, stone and other materials. There was no concern for the possibility that a style might arise from the natural expression of the material, with no reference to the styles associated with other materials.

In spite of considerable opposition from architects, "to the owner of property they offered the advantages of cheapness with great rapidity of construction, while giving ample floor space and

<sup>25</sup> Daniel D. Badger, Illustrations of Iron Architecture, New York, 1865.

<sup>26</sup> Ibid., p. 9.

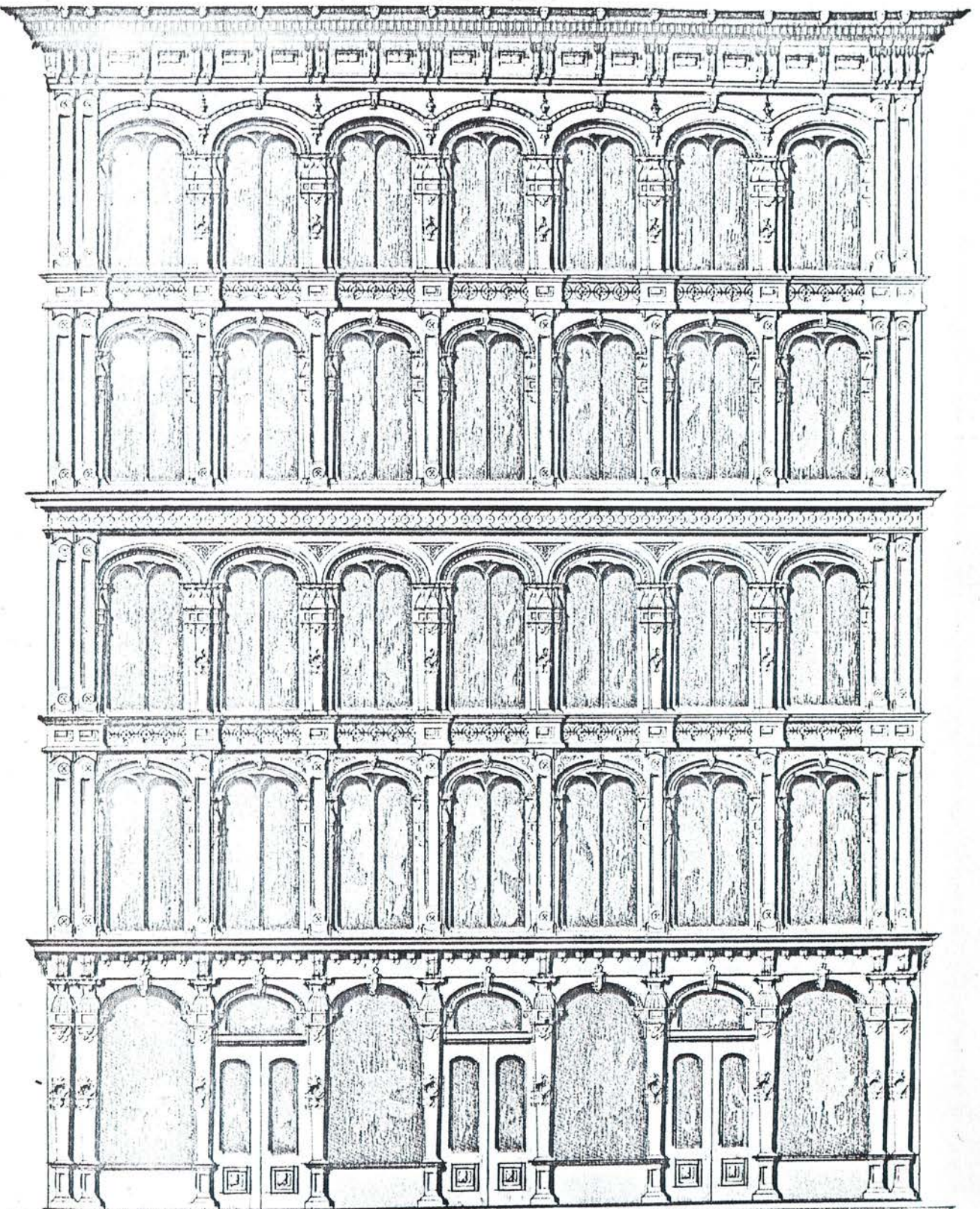
<sup>27</sup> By 1865, Badger had erected no less than 400 iron fronts in New York.

<sup>28</sup> Daniel D. Badger, op. cit., pp. 5-6.



Design for Store Front.

No 32



10th of Sarong Major & Co. 1865.

Plate 102. Store front, Albany, N.Y., by Daniel Badger, before 1865.



Elevation for Dwelling House

Plate .VII.

No. 43

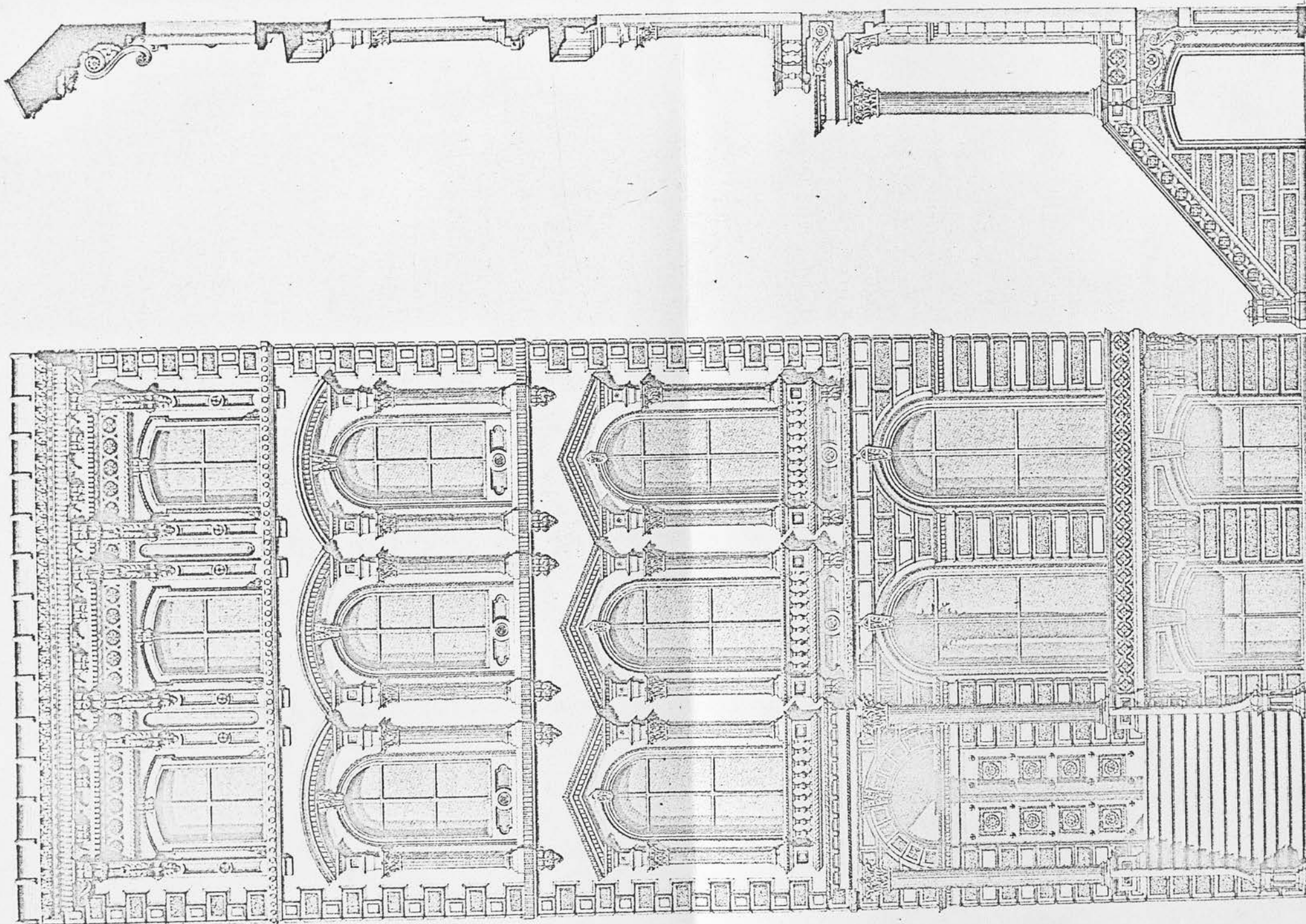


Plate 103. Design for an iron front for a dwelling house, by Daniel Badger, before 1865.

ARCHITECTURAL IRON WORKS, NEW-YORK.

Lab. of Sarony, Major & Knapp, N.Y.

Plate AT  
Designs for Store Fronts.

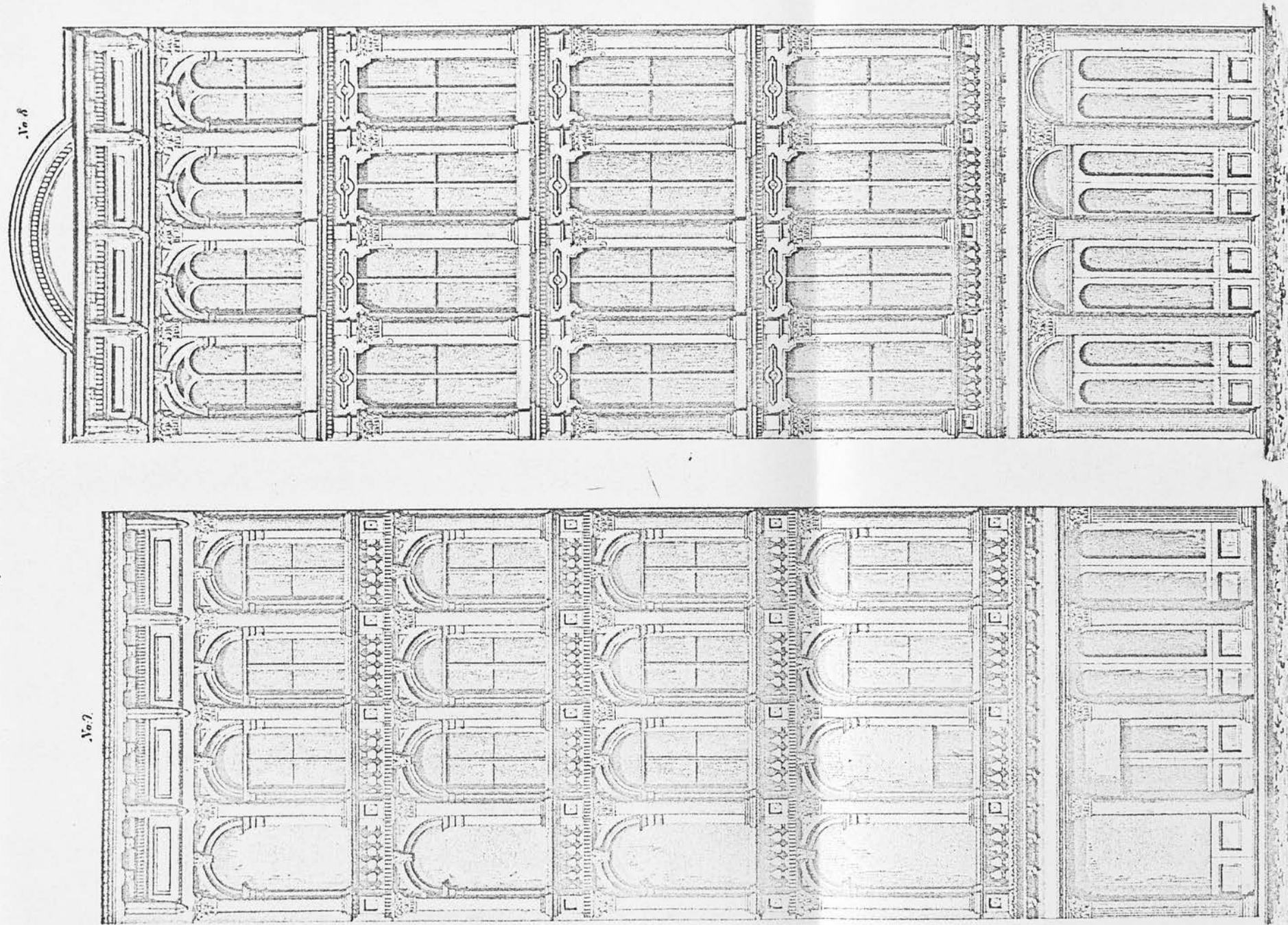
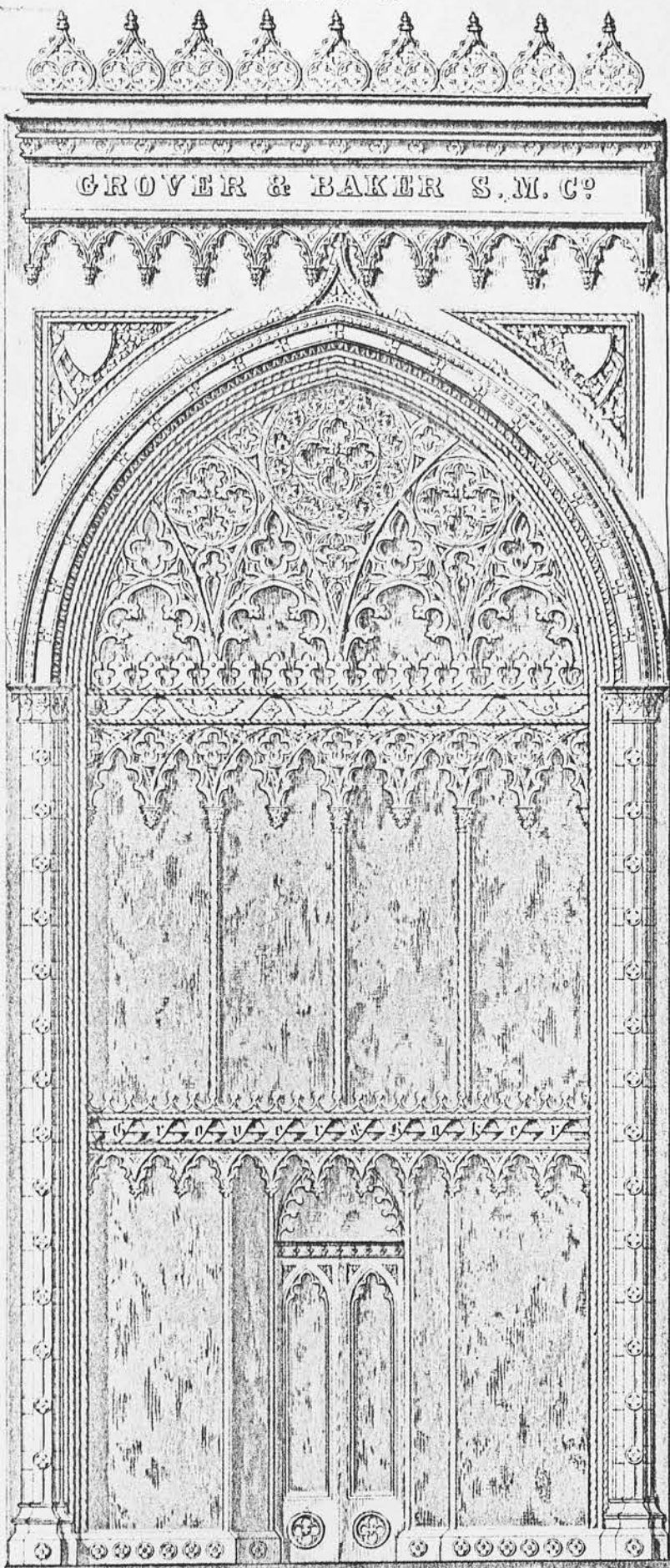


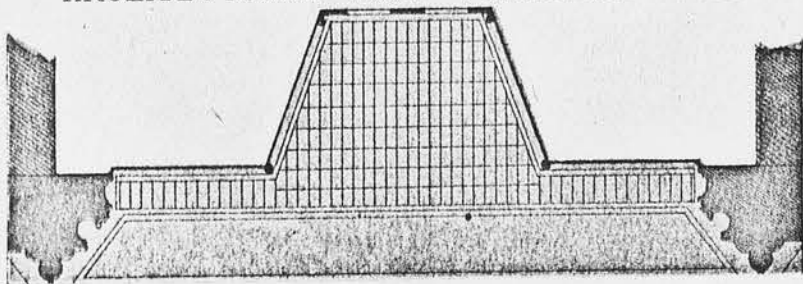
Plate 104. Designs for store fronts, by Daniel Badger, before 1865.  
 No. 7., Walker Street, New York.  
 No. 8., 53 Broadway, New York.



Total height 33' 6"



ARCHITECTURAL IRON WORKS - NEW-YORK.



light. All that was necessary to secure such an edifice was the filling out of a blank form, giving a few particulars of size, etc., and out of the stock in the foundry yard the building was picked in section, rivetted together, and almost to an hour the job was turned over as "a magnificent commercial palace" to the delighted investor. Every moulding and feature was designed as an imitation of stone, and when painted, the iron masks passed very well to the popular eye and at the proper distance as marble."<sup>29</sup>

Such commercial success for iron fronts was not repeated in Britain. Only a handful of examples were built and these only occurred in cities that were very closely connected with a vigorous iron industry. However they do make a very sharp contrast with the American fronts. In Glasgow where several were built in the 1850's a quite remarkable originality in design was achieved.

The most original and beautiful of the Glasgow fronts was Gardner's building in Jamaica Street, built in 1855-6. (See Plate 106). The architect, John Baird worked in close association with the ironfounder, Robert McConnel.<sup>30</sup> There is great subtlety in

<sup>29</sup> Iron Fronts - New Office Buildings, The American Architect and Building News, July 5th 1879, p. 6.

<sup>30</sup> The internal construction of Gardner's employed a beam system that was patented by McConnel in 1855. (No. 1085, 14th May 1855, Improvements in Beams or Girders for Building or Structural Purposes). Beams based on the same patent were used for a cast iron fronted building at 217-21, Argyle Street, (Architects, John Baird and James Thomson). See the Builder, October 3rd, 1863, p. 713.





Plate 106. Gardner's iron building, Jamaica Street, Glasgow, by John Baird, 1855-6.

the design of the facade. Each bay is divided into five lights (four on the side elevation) by moulded iron mullions. There is a delicate change in the fenestration from floor to floor. At first floor level the windows have flattish segmental heads, at second floor, nearly semi-circular heads and on the top floor completely semi-circular heads and here the mullions turn into tiny pilasters with foliated capitals. In addition the floor heights diminish towards the top of the facade. Although the facade makes gentle allusions to classical precedents in the cornice and balustrades, the general effect is one of originality expressing the lightness and elegance of iron.<sup>31</sup> Such a facade could never be constructed in any other material.

Further down the same street is another facade which demonstrates an alternative original approach to the design of an iron front. This is the Collosseum Building<sup>32</sup> (See Plate 107) by H. Barclay and A. Watt built for the showrooms and office of an iron merchant in 1857. Here the architects linked the floors by giant pilasters with flat arches above and contained the small arches of the mullioned lights within them. None of the decoration is classically inspired, the only historical allusion is the faintly mediaeval character of the cornice.

<sup>31</sup> For a very damning criticism of this building see the Building Chronicle, March 1857, p.169.

<sup>32</sup> The Building Chronicle, February 1st 1857. Although much altered this facade still stands but is under threat of demolition at present.



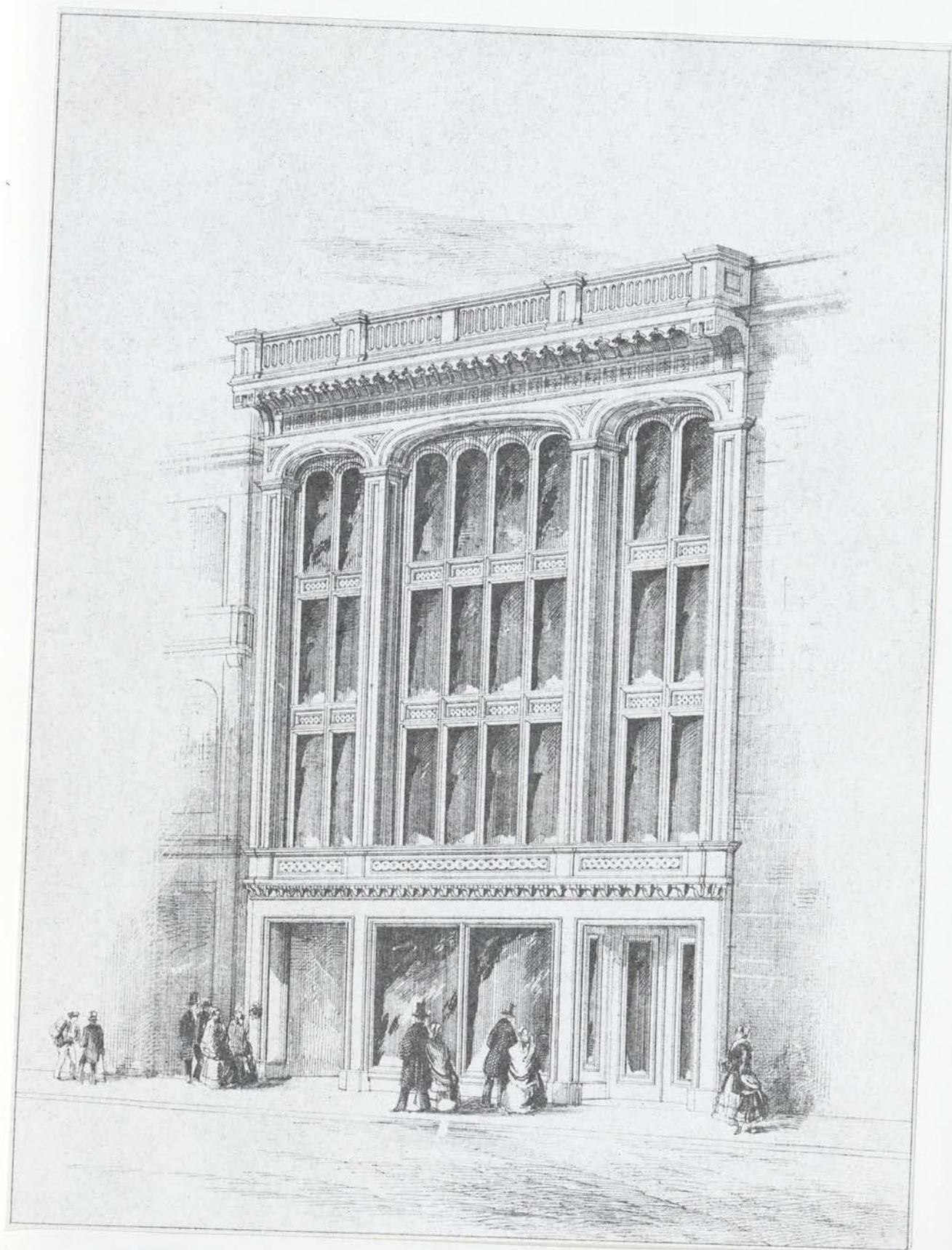


Plate 107. Collosseum Building, Jamaica Street, Glasgow, by H. Barclay and A. Watt, 1857.

For pure original design in iron the finest example in Britain is surely Peter Ellis' Oriel Chambers in Liverpool of 1864. (See Plates 108 and 109). The building has a strong well composed facade of sparsely decorated pilasters in stone linking the floors and combined at the top by a vigorous and original cornice. The exquisitely light bay windows framed in cast iron are woven through this strong composition. Although this cannot be termed an 'iron front' in the strictest sense of the term, it does suggest a mode of composition that could have provided a completely new approach to the problem of style.

Although there were a few examples later in the 70's (Plate 110 is an iron front in Derby designed by Owen Jones in 1872<sup>31</sup>) the iron front business in Britain never established itself sufficiently to become a trade providing an 'off-the-peg' service, as it did in America.

<sup>31</sup> The Architect, May 18th 1872, p. 256. This facade was for the ironfounders J. and G. Haywood and would have been in iron primarily as an advertisement for the quality of the firms own ironwork.



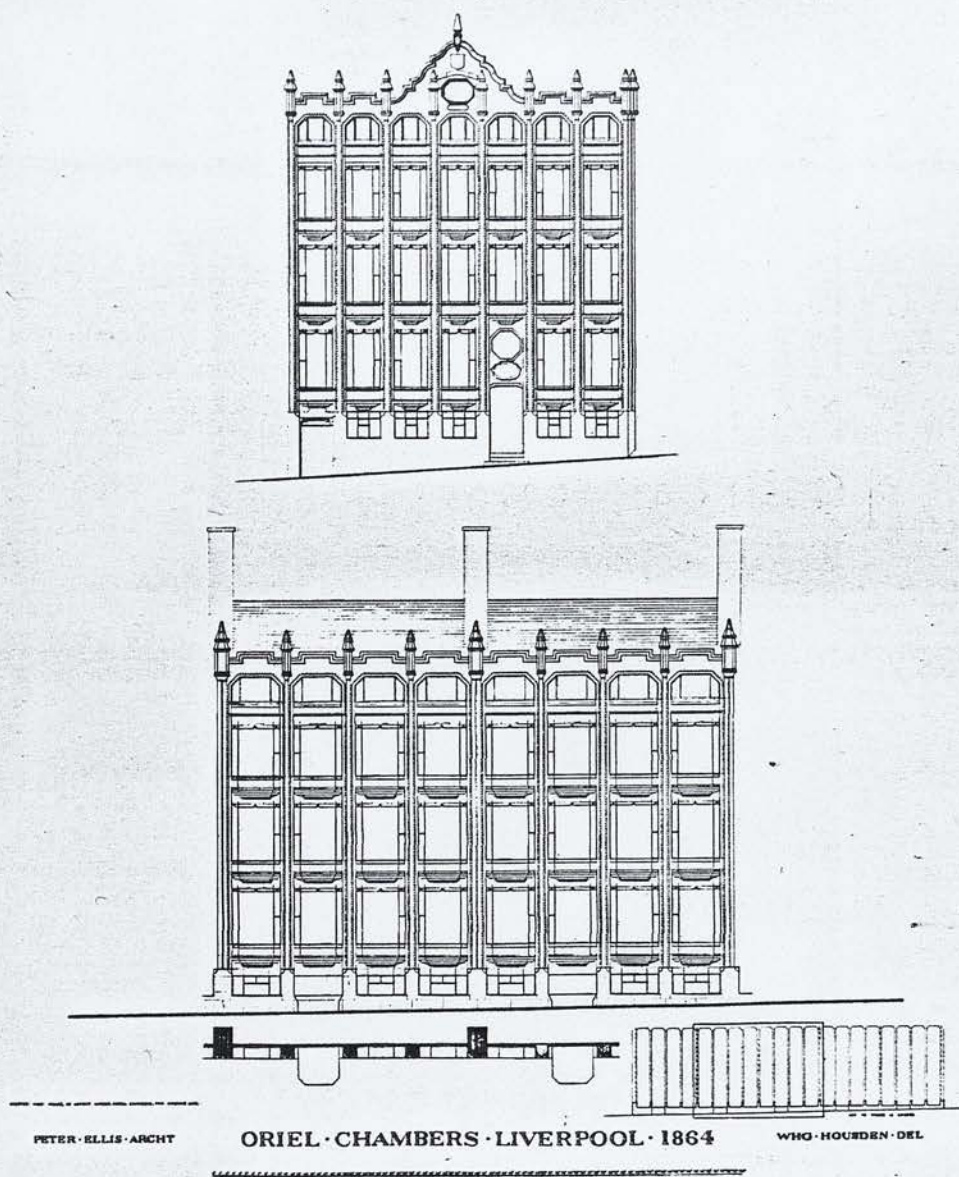


Plate 108. Oriel Chambers, Liverpool, by Peter Ellis, 1864.  
Elevations.

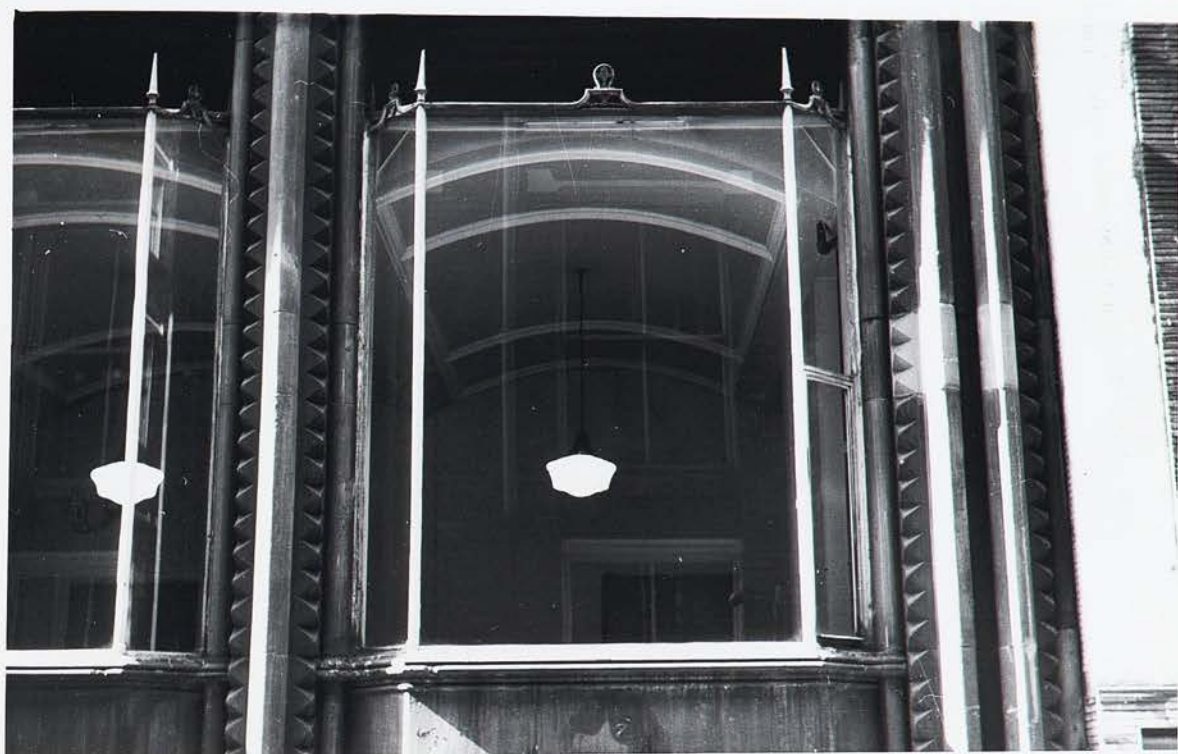


Plate 109. Oriel Chambers, Liverpool. Detail of bay window.

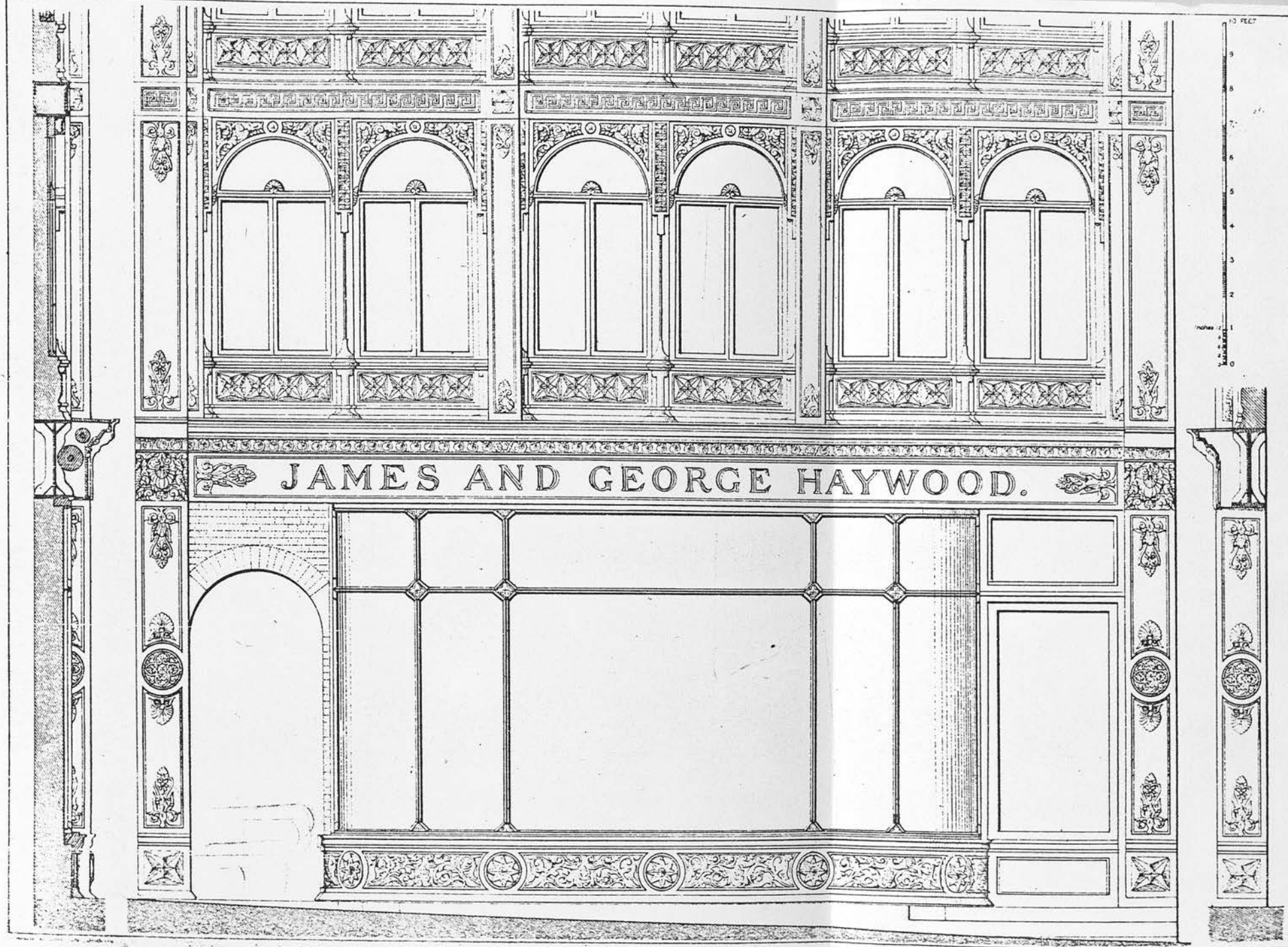


Plate 110. Iron front, Irongate, Derby, by Owen Jones, 1872.

The introduction of iron into architecture in the 18th century, and its growing use in the 19th century, had a small but marked effect on architectural theory.

Cast iron, with its strength in compression, and wrought iron, with its considerable resistance to extension, brought about significant changes in the structural system of buildings. The use of iron for a building frame was a revolutionary step, as it allowed for a more flexible and stronger structure. The introduction of iron led to a new style of architecture, one that was more functional and less ornate. The structure of buildings was no longer a mere shell, but a part of the design. The use of iron also led to a new style of architecture, one that was more functional and less ornate. The structure of buildings was no longer a mere shell, but a part of the design. The use of iron also led to a new style of architecture, one that was more functional and less ornate. The structure of buildings was no longer a mere shell, but a part of the design.

## CHAPTER VIII

The contribution of iron to the search for a new style of Architecture. (1805-1880).

The search for a new style of architecture was a long and difficult process. Architects were looking for a new way to express themselves, and iron was the key to this new style. The use of iron allowed for a more functional and stronger structure, and it was this that led to a new style of architecture. The search for a new style of architecture was a long and difficult process. Architects were looking for a new way to express themselves, and iron was the key to this new style. The use of iron allowed for a more functional and stronger structure, and it was this that led to a new style of architecture.

See Chapter I, p. 35.

M., *On the Effect which should result to Architecture, in regard to Design and Arrangement*, from the nature of materials, both in the construction of buildings, and in the execution of the work. Vol. IV, 1837, pp. 477-481.

*Ibid.*, p. 267.



The introduction of iron into architecture in the 18th century, and its growing use in the 19th century, had a small but marked effect on architectural theory.

Cast iron, with its strength in compression, and wrought iron, with its considerable resistance to tension forces, brought about significant changes in the possible structural systems that could be chosen for a building. From a theoretical point of view, the introduction of iron upset the existing canons of architecture, in as much as these had been closely related to the traditional materials - stone, timber and brick. The structures of buildings could have a much lighter appearance, and spans could be much greater. It was no longer relevant to apply 'correct' proportions that had been evolved in, for example, stone to the new material, iron.

Although Repton was the first to hint at this problem<sup>1</sup> as far back as 1805, it was not until 1837 that an anonymous article was published specifically examining this problem.<sup>2</sup> The author's purpose was quite simple. He thought it desirable that architects should adapt their designs to the new material, rather than adapt the material to their designs. In referring to the role of historical precedent, he advises the architect to "seek to obtain . . . a correct translation of the philosophy, not the poetry, of ancient architecture into the iron tongue."

<sup>1</sup> See Chapter I, p. 35.

<sup>2</sup> M., On the Effect which should result to Architecture, in regard to Design and Arrangement, from the general introduction of Iron in the construction of Buildings, The Architectural Magazine, Vol. IV, 1837, pp. 277-87.

<sup>3</sup> Ibid., p. 287.

When he worked out his own designs for a church and a house, the result was rather bizarre. As he admitted, "we see that the effect of the use of iron in some buildings may reasonably be estimated as giving encouragement to a modified species of the Gothic style, partaking of the lighter character of the Saracenic".<sup>4</sup>

Rather the same conclusions were drawn by Ambrose Poynter in an essay awarded a medal by the Institute of British Architects in 1842.<sup>5</sup> Poynter expressed the need for a new style applicable to iron, but admitted that a "style, like a language must be the growth of time and circumstance".<sup>6</sup> He examined and compared ancient designs in marble and bronze and showed how the material radically affected the proportions. As with the previous writer, he settled for Gothic as the style most likely to be adapted to iron as it was based on the "prevalance of the perpendicular line."<sup>7</sup> He claimed that it had been the intention of mediaeval architects to achieve the maximum slenderness in the design of columns and in the 19th century it was possible "to arrive at a degree of lightness, of which the Gothic architects could only dream."<sup>8</sup>

<sup>4</sup> Ibid., p. 282.

<sup>5</sup> Ambrose Poynter, On the effects which should result to Architectural Taste with regard to Arrangement and Design from the General Introduction of Iron in the Construction of Buildings, 1842. (R.I. B. A. Library Pamphlet 01/40).

<sup>6</sup> Ibid., p. 1.

<sup>7</sup> Ibid., p. 4.

<sup>8</sup> Ibid., p. 4.

At about the time that Poynter was writing his essay, Pugin's 'True Principles' was published, with its famous "grand rules for design".<sup>9</sup> The second of these rules states "that all ornament should consist of enrichment of the essential construction of the building".<sup>10</sup> In spite of this optimistic note at the start of his book, it is disappointing to find later on, that although he viewed cast iron "as a most valuable invention",<sup>11</sup> he did not consider it possible to use it as the principal constructional material because it could "rarely be applied to ornamental purposes".<sup>12</sup> Another objection to iron was that it was so much stronger than stone. If, for instance, the mullions of a window (he was of course only thinking of a mediaeval window) were made in iron, and if they were to be consistent with the material, they would be "painfully thin" and "devoid of shadow, and out of all proportion to the openings in which they are fixed."<sup>13</sup> His final objection, which Ruskin took up later,<sup>14</sup> was that because cast iron was moulded it was "a source of continual repetition, subversive of the variety and imagination exhibited in pointed design. A mould for casting is an expensive thing; once got it must be worked out. Hence we see the same window in greenhouse, gate-house, church and room; the same

<sup>9</sup> A.W.N. Pugin, The True Principles of Pointed or Christian Architecture, 1841, p. 1.

<sup>10</sup> Ibid., p. 1.

<sup>11</sup> Ibid., p. 29.

<sup>12</sup> Ibid., p. 29.

<sup>13</sup> Ibid., p. 29.

<sup>14</sup> For a discussion of Ruskin's views on iron see Chapter IV, pp. 58-60.

strawberry-leaf, sometimes perpendicular, sometimes horizontal, sometimes suspended, sometimes on end; although by the principles of pure design these various positions require to be differently treated."<sup>15</sup> The same idea is developed in his 'Apology' where he rejects the use of iron "as a meagre substitute for masons' skill."<sup>16</sup>

It is not surprising that Pugin could not conceive of a new style for iron. He felt that the true spirit of 'pointed architecture' could only be revived by the faithful study and 'correct' use of mediaeval styles and iron was, of course, peripheral to this central purpose.

Two years after the 'Apology' appeared, a most extraordinary book was published which had all the promise of solving the question of a new style of architecture using iron.<sup>17</sup> The title page of William Vose Pickett's book (See Plate 111) offers the highest expectations, but the text is a bitter disappointment. It is written in flowery, and almost incomprehensible language. The book also suffers from a total lack of illustrations. It would appear that its effect on the architectural profession, in spite of considerable efforts by Pickett<sup>18</sup>, was negligible.

<sup>15</sup> A. W. N. Pugin, True Principles etc., pp. 29-30.

<sup>16</sup> A. W. N. Pugin, An Apology for the Revival of Christian Architecture, p. 41.

<sup>17</sup> William Vose Pickett, New System of Architecture, 1845.

<sup>18</sup> Pickett patented his principles in 1844 (No. 10175, 7th May 1844) and subsequently published a series of articles attempting to promote his ideas with evangelical zeal. For the list of articles see P. Collins, Metallurgic Architecture 1844, Architectural Review, Oct. 1961, pp. 267-8. To this list should be added Vulcanian Architecture, The Athenaeum, (No. 853) March 2nd. In addition, Pickett attempted to press his ideas on the Ecclesiological Society at the time of their publication of Slater's design for an iron church. See The Ecclesiologist, Vol. XVII, August 1856, pp. 280-1 and December 1856, p. 463.



NEW SYSTEM  
OF  
ARCHITECTURE,  
FOUNDED ON  
THE FORMS OF NATURE,  
AND DEVELOPING  
THE PROPERTIES OF METALS;  
BY WHICH A HIGHER ORDER OF BEAUTY,  
A LARGER AMOUNT OF UTILITY,  
AND VARIOUS ADVANTAGES IN ECONOMY,  
OVER THE PRE-EXISTENT ARCHITECTURES,  
MAY BE PRACTICALLY ATTAINED:  
PRESENTING ALSO,  
THE REGULAR AND IMPORTANT ADVANTAGE OF BEING  
COMMERCIAL,  
ITS PRODUCTIONS FORMING FITTING OBJECTS FOR  
EXPORTATION.

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BY  
WILLIAM VOSE PICKETT.

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LONDON:—LONGMAN & CO.

1845.

However, some 4 years after the book appeared a two page pamphlet summarizing his 'New System of Architecture' was published.<sup>19</sup> This has the great advantage of illustrations although they are of a rather abstract character. The whole argument for iron is condensed in the paper to the formation of a new style based on four "primary principles".

The first principle involved the use of "hollow iron walls" with a "chased ornamental surface"<sup>20</sup> as an alternative to solid masonry walls. This principle would seem to be merely a decorative version of the technique that had evolved in portable buildings mainly to improve the thermal insulation. The second principle was purely decorative in its intentions. Pickett called it "interstitial ornamental form".<sup>21</sup> It is difficult to understand his intentions here, but it seems to be based on finely decorated metallic ornament being applied to a building as a jewel would be set in a brooch, except that they would be set some distance from the wall surface to produce "protean effects through the projection of its shadows".<sup>22</sup>

The third principle is a rather less elusive one. This simply refers to the use of iron to produce suspension structures. He

<sup>19</sup>William Vose Pickett: New System of Architecture adapted to the Properties of Iron and other Metals, n.d. The only surviving copy of this so far located is attached to the copy of his 1845 book in the RIBA Library.

<sup>20</sup>Ibid., p. 1.

<sup>21</sup>Ibid., p. 2.

<sup>22</sup>Ibid., p. 2.

saw its main advantage as the reduction of obstruction caused by columns and piers. Pickett omits to mention a vital factor that only wrought, and not cast iron would be suitable for such structures and one suspects from this omission that his understanding of the engineering principles involved was almost negligible.

His fourth principle, the "substitution of curves",<sup>23</sup> would seem the only one to have really developed in any way. Collins<sup>24</sup> has suggested a direct connection between Pickett's fourth principle and Jobard's Metallurgic Architecture and its effect on Belgian Art Nouveau ironwork. In addition there may be a similar connection with Viollet-le-Duc's drawings of ironwork in the 'Entretiens' with its flowing curves and volute forms.<sup>25</sup> Pickett's book and his subsequent papers represent the last attempt at producing a new explicit theory of iron architecture.

As already explained,<sup>26</sup> the building for the Great Exhibition had an enormous impact on the architectural profession, and some felt that it had inaugurated a new style of architecture. Although the style that this building displayed was never codified into an explicit theoretical style of iron architecture, the building, nevertheless,

<sup>23</sup>Ibid., p. 2.

<sup>24</sup>P. Collins op. cit., p. 263.

<sup>25</sup>E.E. Viollet-le-Duc, Entretiens sur L'Architecture, Tome II, p. 126.

<sup>26</sup>See Chapter IV, pp. 57-8.

embodied an implicit natural style which had a powerful influence thereafter. What were the components of this style? The structure was built up by using repetitive bays, and therefore displayed a certain quality of indeterminacy.<sup>27</sup> The building had a lightness and elegance because of the use of iron, with its thin circular columns and lightweight trusses. The resultant spatial effect was entirely novel, creating an illusion of 'boundless space', which was heightened by the liberal use of glass. The building had no applied decoration, for the modelling of components was entirely based on the constructional exigencies of the building. These stylistic attributes of lightness, elegance, spatial and formal indeterminacy, and, modelling based on constructional expediency, may be said to be the components of a new style based on iron. The Great Exhibition Building was certainly the highest achievement in this style.

The Great Exhibition building became an established reference point for all subsequent discussion on the problem of a style of architecture for iron. Matthew Digby Wyatt, who had written such an excellent technical description of the building,<sup>28</sup> seemed to accept the achievement of a new style in the building and predicted that "the

<sup>27</sup> It was quite unimportant, from the point of view of appearance, that the Great Exhibition building was 77 bays long. The number of bays could have been increased or decreased without essentially altering the appearance.

<sup>28</sup> See Chapter IV p.51 note 24.



novelty of its forms and details will be likely to exercise a powerful influence upon national taste."<sup>29</sup> He saw the Exhibition Building as part of an emergenging tradition established by the "imperative requirements and giant mould of modern civil engineering."<sup>30</sup> From this tradition he saw the development of a new style with "its own scale of form and proportion - a vocabulary of its own."<sup>31</sup>

In the next volume of the Journal of Design an anonymous writer<sup>32</sup> makes an even more extravagant claim for the role of iron as a unique element in a new style. He argues that the great styles of the past sprang "from making best use of the available building materials" and drew out "the best resources of these materials as regards their capabilities for strength, endurance, usefulness and beauty."<sup>33</sup> Iron and glass could therefore, as the unique materials of the 19th century, be the generator of a new architecture which would give "full freedom to the resources of the materials."<sup>34</sup>

<sup>29</sup> M.D. Wyatt, Iron-work and its Principles of Treatment, Journal of Design and Manufactures, Vol. IV (1850/1) p.78. An amended version of this text is incorporated in M. D. Wyatt, Metal Work and its Artistic Design, 1852 (pp. XIII - XIX).

<sup>30</sup> Ibid., p.77

<sup>31</sup> Ibid., p.78

<sup>32</sup> 'Palladio Redivivus', Prospects of Iron and Glass Edifices and of Novel Forms of Architecture arising from the Use of these Materials, Journal of Design and Manufactures, Vol. VI (1851/2) pp.16-19 and 70-74.

<sup>33</sup> Ibid., p.18

<sup>34</sup> Ibid., p.74

Gilbert Scott echoes the same sentiment when he argues that iron is "the material pre-eminently of our own day"<sup>35</sup> and its adoption would parallel the mediaeval builders' use of stone and timber. Scott viewed the Crystal Palace as a unique building which could not be used as a precedent for the future development of an iron style. The development of the material would have to happen within the growth of the Gothic style - "Iron constructions are, if anything, more suited to Gothic than classic architecture"<sup>36</sup> - and the burden of the task lay with "architects engaged in our revival," to render to metallic construction "the charm of beauty to what is at present but crude, unadorned construction."<sup>37</sup>

In summary most critics did not recognize the natural style embodied in the Crystal Palace.<sup>38</sup> James Fergusson although conceding the building "has had a considerable effect on a certain class of designs"<sup>39</sup>, still classified the building as "an admirable

<sup>35</sup> G.G. Scott, Remarks on Secular and Domestic Architecture, 2nd Edition, 1858, p.112.

<sup>36</sup> Ibid., p.111.

<sup>37</sup> Ibid., p.113.

<sup>38</sup> A rare instance of a 19th century appreciation of this style was given by an American architect, Henry Van Brunt, in a paper to the American Institute of Architects in 1858. "Now inasmuch as nature, when she urges upon us the use of iron, actually demands from us a mechanical treatment of it with the mould, we may fairly expect that the principle of monotony, usually so repugnant to a stone architecture, may under these more favourable circumstances be elevated to a beauty and an honour." (Cast Iron in Decorative Architecture, The Crayon, January 1859, p.18).

<sup>39</sup> James Fergusson, (History of the Modern Styles of Architecture, 1862, p.482.

piece of Civil Engineering".<sup>40</sup> As already explained<sup>41</sup> his objection was its lack of solidity and permanence.

This objection also appears in Samuel Huggins' most interesting account of the "Style of the Future" in his book of 1863.<sup>42</sup>

"Iron, I conceive, is destined to play a very important part in the art of the future. We cannot, I think, except in very few cases, have edifices all iron and glass; and in no case can we have a truly noble - that is, a high-class - edifice confined to these two materials. Masonry or brickwork is essential to such a structure, of which it must at least form the main body and bulk, and give stability to the whole, while uniting it to the ground. But iron may be very extensively employed notwithstanding; and, though every new material must be used according to its natural properties, yet I do not see the difficulty in harmonising iron with stone that some anticipate. The fact is, while iron is being moulded and rendered meet for union with the more massive material, the same preparatory process must be undergone by the stone, that they may meet each other half-way. If this were done, I feel convinced that we could have very noble and beautiful edifices, into the composition and ornamentation of which iron should enter in a much larger proportion than it has ever done, giving them a certain aerial

<sup>40</sup>Ibid., p. 482.

<sup>41</sup>Chapter IV, pp. 57-8.

<sup>42</sup>Samuel Huggins, The Course and Current of Architecture, 1863, pp. 163-187.

and fairy-like effect, of which masonry alone is incapable."<sup>43</sup>

In spite of these hopeful predictions, Huggins felt that the search for a new style as an overt pursuit was unlikely to succeed.

"To me all history of the rise and mutations of styles conspires to show the folly of our hankering after a new style; every style of whose origin we have any knowledge having arisen not from an act of the will, or some one setting about the invention of a new style, but, spontaneously, out of new circumstances, brought on by some great political, intellectual, or religious revolutions, as the rise of new or mingling of old nations, propagation of new religions, revival of letters and kindred arts - events which do not characterise the present age."<sup>44</sup>

Such a statement did not deter George Aitchison in a paper read at the Royal Institute of British Architects in 1864,<sup>45</sup> urging architects to "throw aside all our old traditions; let us hold in abomination the five orders, coronas, triglyphs, curled cantilevers, the egg and tongue, and the acanthus - cusps, crockets and the pointed arch",<sup>46</sup> and turn their attentions to inventing a new style using iron. Hostile objections to this radical approach came in the discussion after the presentation

<sup>43</sup>Ibid., p. 177.

<sup>44</sup>Ibid., p. 163.

<sup>45</sup>G. Aitchison, (the Younger) On Iron as a Building Material, RIBA Papers Vol. XIV, pp. 97-107.

<sup>46</sup>Ibid., p. 105.



of this paper, the most vociferous from William White. White presented a paper to the Institute the next year exploring the same subject.<sup>47</sup>

Paul Thompson was the first to show the importance of White's views on iron.<sup>48</sup> White's main objection to iron was its high cost, especially in domestic use and for church building. For large scale buildings, exhibition buildings, railway stations and markets it was of course cheaper, but although White found these types of buildings admirable he felt like Fergusson that they lacked the real qualities of Architecture - permanence and solidity.

White felt, unlike Van Brunt, that the repetitive nature of these structures excluded them from the domain of Architecture. "The very necessity for its exact reproduction and vast re-duplication in large and prevailing forms, its uncompromising resistance to any modification of outline, or of treatment in detail, puts it almost beyond the reach of Architectural Art."<sup>49</sup>

The quest for a new style in iron carried on, but, even such a radical opinion as Robert Kerr had become somewhat disillusioned that it would ever become established. In a paper at the RIBA in 1869<sup>50</sup> he

<sup>47</sup>W. White, Ironwork: its Legitimate Uses and Proper Treatment, RIBA Transactions, 1865/6, pp. 15-30.

<sup>48</sup>P. Thompson, The Writings of William White, in Concerning Architecture (edited by John Summerson) 1968, pp. 226-37.

<sup>49</sup>Ibid., p. 17.

<sup>50</sup>Robert Kerr, A Development of the Theory of the Architecturesque, RIBA Sessional Papers, 1st Series, Vol. 19 (1868-9), pp. 89-104.

pleaded that although we had been in possession of iron as a building material for many years, no new style had emerged because it would take "ages to effect a real change of style".<sup>51</sup>

This rather defeated attitude<sup>52</sup> is reflected in his tentative recommendations to architects, in a paper read at the Architectural Association in 1876,<sup>53</sup> that wrought iron plate girders could be "pierced or perforated to almost any desired extent or design"<sup>54</sup> and that the rivets could be arranged in patterns.

After 1870 the hope that a new style could take root had faded away. From that date iron was seldom offered as the material that could transform Victorian architecture from its confused eclecticism to a pure and original style.

Two important factors sealed the hopes of the theorists. Firstly, with the introduction of steel as a more economical framing material in the 1880's arguments about the decorative treatment of iron became obsolete. Secondly, although iron was an incombustible material, when the Chicago architects of the 1880's invented a fireproof building

<sup>51</sup>Ibid., p. 99.

<sup>52</sup>For a full discussion of the writings of Kerr on the theme of the failure of late Victorian Architecture to evolve a new style, see J. Summerson, Victorian Architecture, 1970 Chapter I, The Evaluation of Victorian Architecture: The Problems of Failure, pp. 1-18.

<sup>53</sup>Robert Kerr, The Treatment of Scientific Engineering Artistically, Builder, 1876, pp. 235-6.

<sup>54</sup>Ibid., p. 235.

system with the metal frame<sup>55</sup> enclosed in terra cotta or concrete, the expressive nature of the building no longer relied on any decorative treatment of the metal as it was entirely hidden from view.

After these events the use of iron did not lie at the centre of architectural polemics and its use only continued where fireproofing did not present a problem (i.e. in single-storey structures).

However, even as late as 1905, the dream was still just alive.

"If we are to make iron our main constructive element we must break with the old traditions of brick and stone, and adopt a method of design more suitable to the new material." "Why should not the superstructure of the shop-front be framed with a skeleton of iron filled in with nogging or thick hollow walls, faced perhaps with glazed bricks in colour, for enclosing the habitable part of the house. On the ground floor the great bressummer with its supports would be exposed to view, and the plate-glass would be framed between them, and not in front so as to hide them. Each upper storey might slightly overhang that below to protect the great girder on which it rests, and all the skeleton of ironwork would be exposed on the surface in the same way as the framing of half-timber at Shrewsbury or Chester ...." But here the author admits the insoluble obstacle to his dream. "A building of this construction would be rather a fascinating experiment, but I may add it

<sup>55</sup>Initially employing an iron structure but later replaced by steel as the cost of steel gradually fell.

would be condemned by the by-laws of every local authority in the kingdom."<sup>56</sup>

#### APPENDIX I

<sup>56</sup>T.G. Jackson, Reason in Architecture, 1905, pp. 169-171.



## APPENDIX I

Chronological sequence of the principal examples of iron architecture, including notable projects and products of iron bridges, etc.

- 1) Iron columns, Hospital, Glasgow, 1791, designed by the 18th-century architect Christopher Wren.  
J. Macdonald, Glasgow Iron Columns, 1791, Architectural Review, July 1941, pp. 53-54.
- 2) St. John's, Liverpool, 1796-2, built during the war.  
(Designed 1867) Architect unknown.  
J. A. Smith, Memorial of Liverpool, 1874, Vol. II, p. 220.  
The Engineer in Liverpool, 1874, p. 220.
- 3) Iron bridge at Coalbrookdale, Shropshire, 1779.  
Thomas Telford and Abraham Darby, Jr.  
John Smith, History of Mr. Telford's Works, 1834, p. 10.  
The Engineer in Liverpool, 1874, p. 220.
- 4) Iron bridge at Coalbrookdale, Shropshire, 1779.  
Thomas Telford and Abraham Darby, Jr.  
John Smith, History of Mr. Telford's Works, 1834, p. 10.  
The Engineer in Liverpool, 1874, p. 220.
- 5) Iron bridge at Coalbrookdale, Shropshire, 1779.  
Thomas Telford and Abraham Darby, Jr.  
John Smith, History of Mr. Telford's Works, 1834, p. 10.  
The Engineer in Liverpool, 1874, p. 220.
- 6) Iron bridge at Coalbrookdale, Shropshire, 1779.  
Thomas Telford and Abraham Darby, Jr.  
John Smith, History of Mr. Telford's Works, 1834, p. 10.  
The Engineer in Liverpool, 1874, p. 220.

## APPENDIX I

### Chronological catalogue of the principal examples of iron architecture, including unbuilt projects and Patents of iron construction.

- 1) Iron columns, House of Commons, 1706-7. (destroyed by fire 1834) Christopher Wren.  
J. Harris, Cast Iron Columns, 1706, Architectural Review, July 1961, pp. 60-61.
- 2) St. Anne's, Liverpool, 1770-2. Iron gallery supports. (Demolished 1867) Architect unknown.  
J.A. Picton, Memorials of Liverpool, 1875, Vol. II, pp. 308-309.  
The Stranger in Liverpool, 3rd Edition Liverpool, 1812, p. 97.
- 3) Iron Bridge at Coalbrookdale, Shropshire, 1778-9.  
Thomas Pritchard and Abraham Darby III.  
John White, Notice of Mr. Pritchard's Gradual Progress in the Application of Iron to the Erection of Bridges, The Philosophical Magazine and Annals of Philosophy, February 1832, pp. 81-2.  
Charles Hutton, Tracts on the many interesting parts of the Mathematical and Philosophical Sciences, 1812, Vol. I, Tract VI, p. 145.  
R. Maguire and P. Matthews, The Ironbridge at Coalbrookdale, Architectural Association Journal, July/August 1958, pp. 30-45.
- 4) Patent No. 1667, 26th August 1788. Constructing arches, vaulted roofs and ceilings either in iron or wood.  
Thomas Paine.  
Reprinted in (Philip S. Foner), The Complete Writings of Thomas Paine, New York 1945, pp. 1031-4.
- 5) Mill at Derby, 1793-3. (dem. c. 1860).  
William Strutt.  
A. W. Skempton and H. R. Johnson, The First Iron Frames, Architectural Review, March 1962, pp. 175-83.
- 6) Patent No. 2066 18th September 1795. Making, uniting and applying cast-iron blocks in lieu of key stones, in the construction of arches.  
Rowland Burdon.  
Reprinted in The Repertory of Arts and Manufactures, Volume V, 1796, pp. 361-4.

- 7) Bridge over the Wear at Sunderland, 1793-6 (demolished c. 1850)  
Rowland Burdon and Thomas Wilson.  
The Repertory of Arts and Manufactures, Vol. V, 1796, pp.364-8.  
Charles Hutton, op.cit. pp.146-7.  
Robert Stephenson, Iron Bridges, Encyclopaedia Britannica, 8th Edition 1856, Volume 12, pp.577-80.
- 8) Shrewsbury Mill, Castle Foregate, 1796-7.  
Charles Bage.  
A.W. Skempton and H.R. Johnson, op.cit.
- 9) Patent No.2165 7th February 1797, Constructing bridges of plate-iron etc.  
John Nash  
Reprinted in The Repertory of Arts and Manufactures, Volume VI, 1797, pp.361-8.
- 10) Patent No.2410, 10th June 1800, A New Arch or Method of Making and Constructing Bridges, Warehouses and other Buildings etc.  
Samuel Wyatt.
- 11) Bridge over the Rio Cobre, Spanish Town, Jamaica, 1801.  
Designer unknown.  
Walker Foundry, Rotherham.  
J.G. James, Some Early Cast Iron Bridges, The Engineer, January 29th 1965, pp.202-5, and August 20th 1965, p.30.
- 12) Kew Palace, Surrey, 1802-11 (dem. 1827-8)  
James Wyatt.  
Anthony Dale, James Wyatt, 2nd Edition, Oxford, 1956, pp.186-9.
- 13) Patent No.2635, 23rd July 1802, Uniting, combining and connecting the 'metallic patent blocks' for the construction of arches  
Rowland Burdon.
- 14) Design for Pavilion and Greenhouse, Plas-Newydd, Anglesey, before 1803, (not built).  
Humphry Repton.  
Humphry Repton, Observations on the Theory and Practice of Landscape Gardening, 1805, Plate facing p.106.
- 15) Design for Conservatory, Carlton House, 1803 (not built).  
Humphry Repton  
Dorothy Stroud, Humphry Repton, 1962, p.116 and p.131.
- 16) Patent No.3141, 3rd June 1808, Bridge-floorings or platforms, and fireproof floorings and roofings, for houses, warehouses and mills.  
Ralph Dodd.  
Reprinted in, The Repertory of Arts and Manufactures, Volume XIV, 1809, pp.145-7.

- 17) Library, 3 Soho Square, London 1808. (Richard Payne Knight's House) dem. 1903.  
Mr. Andrews (designer and builder)  
John Harris, C.R. Cockerell's 'Ichnographica Domestica'  
Architectural History, Volume 14, 1971, p.20.
  
- 18) Patent No.3277, 21st November 1809, Cast iron roofs for buildings and covering them with slate.  
John Cragg.  
Reprinted in, The Repertory of Arts and Manufactures Vol.19, 1811, p.132-6.
  
- 19) Theatre Royal, Plymouth, 1811-13.(dem. 1939)  
John Foulston.  
John Foulston, The Public Buildings erected in the West of England, 1838, pp.31-7.  
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- 41) Iron market house, Honduras, 1846.  
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The Builder, April 18th 1846, p. 190.  
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- 55) Iron ball-room, Balmoral, 1851.  
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- 56) Messrs. Miller and Dinsmoor's Shop, Collins Street, Melbourne,  
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- 60) Iron church, Melbourne, Australia, 1853.  
Manufactured by Samuel Hemming, Bristol.  
Illustrated London News, April 30th 1853, p.324  
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- 62) Custom house and warehouse, Payta, Peru, 1853-4.  
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Manufactured by E. T. Bellhouse and Co., Manchester.  
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James Edmeston, Architect (the younger)  
Iron founder: Messrs. Silvester and Co., London.  
Illustrated London News, December 30th 1854, p.689.  
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- 64) Iron theatre, Buenos Aires, 1855.  
Contractor: Richard Turner, Dublin.  
The Builder, November 3rd 1855, p.533.
- 65) Coppins Theatre, Melbourne, 1855.  
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- 66) 'Corio Villa', Geelong, Australia, 1855.  
Manufactured by C. D. Young & Co.  
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- 68) Gardener's Iron Building, Glasgow, 1855-6.  
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 Architects: Sir T. Deane and B. Woodward.  
 Ironwork by F. Skidmore, Coventry.  
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Instrumenta Ecclesiastica, Second Series, 1856, Plates  
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 Architect: Edward Salomons.  
 Contractors: C.D. Young and Co., (William Dredge, engineer).  
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- 74) Kiosk for the Pasha of Egypt, Kafrellais, 1858-60.  
Designed by Robert Stephenson.  
Constructed by Messrs. Grissell and Co., London.  
The Building News, August 5th 1859, p. 708.  
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- 75) Conservatory in the gardens of the Royal Horticultural Society, South Kensington, 1860.  
Designed by Captain Fowke.  
Constructed by Andrew Handyside and Co.  
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- 76) Iron workshop, Royal Dockyard, Kidderpore, India, 1861.  
Constructed by Andrew Handyside and Co.  
E. Matheson, Works in Iron, 1877, pp. 248-9.
  
- 77) The Agricultural Hall, Islington, London, 1862.  
Architect: F. Peck, Maidstone.  
Ironwork by Andrew Handyside and Co.  
(Andrew Handyside), Works in Iron, 1868, pp. 35-7.  
E. Matheson, Works in Iron, 1877, pp. 282-4.
  
- 78) Custom House, Rangoon, Burma(h), before 1863.  
Captain J. T. Williams, Engineer.  
Professional Papers on Indian Engineering, Vol. I, 1863-4, pp. 460-6.
  
- 79) Oriel Chambers, Liverpool, 1864.  
Peter Ellis.  
Quentin Hughes, Seaport, 1964, p. 59, 62, 65. (Chapter IV gives details of all the other iron fronts in Liverpool). See also Architectural History, Vol. I, p. 84-94.
  
- 80) Iron theatre, Hokilika, Sydney, c. 1865.  
Designer unknown.  
The Building News, November 22nd 1865, p. 909.
  
- 81) Iron shelter, Wellington Pier, Bombay, 1866.  
Constructed by Andrew Handyside and Co.  
(Andrew Handyside), Works in Iron, 1868, pp. 44-5.  
E. Matheson, Works in Iron, 1877, pp. 270-1.

- 82) Iron Kiosk, Bombay, 1866-7.  
 Architect: Owen Jones.  
 Engineers: R.M. Ordish and W.H. Le Feuvre.  
 Contractors: Andrew Handyside and Co.  
 The Builder, November 10th 1866, p.833, and December 1st 1866, p.885.  
 The Building News, August 23rd 1867, p.578.  
 (Andrew Handyside), Works in Iron, 1868, p.83 and pp.95-6.  
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- 83) Conservatory for Henry Bessemer, Denmark Hill, London, 1868.  
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 Constructed by Andrew Handyside and Co.  
 (Andrew Handyside), Works in Iron, 1868, pp.93-4.  
 E. Matheson, Works in Iron, 1877, pp.241-2.
- 84) Winter Garden, The Infirmary, Leeds, 1868.  
 Architect: Sir George Gilbert Scott.  
 Engineer: R.M. Ordish.  
 Contractors: Andrew Handyside and Co.  
 (Andrew Handyside), Works in Iron, 1868, pp.92-3.  
 E. Matheson, Works in Iron, 1877, pp.246-8.
- 85) Iron pavilion, Byculla Club, Bombay, 1868-9 (dem.)  
 Designed by R.M. Ordish.  
 Constructed by Andrew Handyside and Co.  
 E. Matheson, Works in Iron, 1877, pp.243-4.  
 Samuel T. Sheppard, The Byculla Club (1833-1916), Bombay, 1916, p.44 and pp.170-1.  
 M. Higgs, The Exported Iron Buildings of Andrew Handyside & Co. Journal of the Society of Architectural Historians, May 1970, pp.177-8.
- 86) Iron building, Nictheroy Gas Works, Rio de Janeiro, Brazil, 1869.  
 Constructed by Andrew Handyside and Co.  
 E. Matheson, Works in Iron, 1877, pp.262-4.  
 M. Higgs, op.cit., p.178.
- 87) Market at Santiago, Chile, 1869.  
 Architects: T.W. Goodman and C.H. Driver.  
 Engineer: Edward Woods.  
 Ironfounder and Contractor: Messrs.Laidlaw and Sons, Glasgow.  
New Market for Santiago, The Architect, April 3rd 1869, pp.179-80.  
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- 88) Watson's Building, Bombay, 1869 (now known as Esplanade Mansion).  
Engineer: R.M. Ordish.  
Ironfounder: James Haywood, Derby.  
The Architect, December 11th 1869, p. 286 and December 18th 1869, p. 298.
- 89) Drill Hall, Derby, 1870.  
Andrew Handyside and Co.  
E. Matheson, Works in Iron, 1877, pp. 274-5.
- 90) Sugar factory, Trinidad, 1871.  
Constructed by Andrew Handyside and Co.  
E. Matheson, Works in Iron, 1877, p. 266-7.
- 91) Cast iron front, Irongate, Derby, 1872. (dem.)  
Manufactured by J. and G. Haywood, Derby.  
The Architect, May 18th 1872, p. 256.
- 92) Market, Place de los Mostenses, Madrid, 1872-3.  
Designed by E. Mathieu.  
Constructed by Andrew Handyside and Co.  
E. Matheson, Works in Iron, 1877, pp. 264-5.
- 93) Market, Place de la Cebada, Madrid, 1872-3.  
Designed by E. Mathieu.  
Constructed by Andrew Handyside and Co.  
E. Matheson, Works in Iron, 1877, pp. 252-3.
- 94) Iron building, Shell Foundry, Woolwich Arsenal, before 1873.  
Designed by officers of the Royal Engineers.  
Constructed by Andrew Handyside and Co.  
E. Matheson, Works in Iron, 1877, pp. 254-5.
- 95) Crystal Palace, Nice, 1876.  
Designed by R.M. Ordish.  
Constructed by Andrew Handyside and Co.  
The Architect, March 18th 1876, p. 180.



## NOTES

### The Exported Iron Buildings of Andrew Handyside & Co. of Derby

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ONE of the major difficulties about all the research on the use of iron in nineteenth-century building is the lack of satisfactory definitions and categories of materials. Books have been written on the history of cast iron which include a great deal about structures using wrought iron and malleable cast iron, as though all were synonymous. The major confusion has been between the history of the structural development of iron and the development of iron architecture. The former is the history of the evolution of fireproof construction leading to the cased metal framed structure. The latter is a term to describe the development of building where iron is the major structural and constructional material and where iron is used as the principal expressive material. Perhaps the most indiscriminately applied term has been prefabricated iron. It would seem logical to use the word only when the building has been totally prefabricated. The nineteenth-century term to describe a totally prefabricated building was a "portable building." The iron buildings of Handyside & Co. that we shall be examining are portable buildings and are further categorized as exported buildings.

Henry-Russell Hitchcock has done more than any other recent author to make us aware of the extent and achievements of the use of iron in nineteenth-century building.<sup>1</sup> However, it seems that this account of the subject may still be partial particularly in the period from the mid 1850s to about 1880. The building of the Brompton Boilers in 1855–1856 did of course bring disillusionment with the use of iron. To a certain extent this extinguished hopes that had been roused by the wonders of the Great Exhibition building and sustained by the many ferro-vitreous buildings that followed in its wake. In spite of this there would appear to have been a flourishing trade in iron buildings well after this date and well into the period of the development of steel framed building.<sup>2</sup> This phase made full use of the then

available wrought iron sections and, perhaps more important, achieved very accomplished work from a decorative point of view. Among the many iron founders who were active in this field during this period the firm of Andrew Handyside & Co. of Derby is worthy of our detailed attention.

The firm was originally established in Duke Street, Derby, in 1818. The site chosen was most significant, for the works adjoined the Derwent, and a short distance from there a connection to the Derby Canal meant that products could be shipped to all parts of the world from the Humber and Mersey ports. In the first thirty years the reputation of the Britannia Iron Works, as it was then called, rested largely on the quality of their ornamental castings known as "Derby Castings." The quality of these was attributed to "the local advantages of good iron and good moulding sand, and partly from the special skill of the moulders who were settled in town."<sup>3</sup> Although we have very scanty evidence of the exact range of their products during this period we do know that they produced quantities of Gothic church windows which were fixed in many new churches in the Midlands. St. John's, Derby, still has its twenty-two cast-iron windows produced at the Britannia Works in 1828. The firm was much admired at this time, not least by the then Earl of Shrewsbury who described them as the most eminent ironfounders of the day.<sup>4</sup> He presumably knew their work from the fine vases, fountains, and the famous cast-iron temple which were erected for him in the gardens of Alton Towers.

The first phase ends with the business being taken over in 1848 by a young Scot named Andrew Handyside. Thereafter the firm is generally referred to by his name. It grew steadily under Handyside and entered many fields of enterprise beyond the work of ornamental casting. Steam engines, machinery of all kinds, constructional ironwork, bridges, roofs, and buildings were produced. Sometime during the late '50s a most important event occurred when the young Ewing Matheson was taken on as a pupil. He was a man who showed early potential, for by the age of twenty-six he had become the manager of Handyside's London office. It is largely through his books<sup>5</sup> that we know the extent and quality of the iron buildings produced by the

1. *Early Victorian Architecture in Britain* (1954), Chaps. xv and xvi. *Architecture: Nineteenth and Twentieth Centuries* (1963, 2nd edition), Chaps 7 and 14.

2. *The Architect's, Engineer's, and Building Trades Directory* (1868).

3. Andrew Handyside and Co., *Works in Iron* (1868), p. 1.

4. *Glover's Directory of Derby* (1858), pp. xxxviii–xxxix.

5. *Works in Iron, Bridge and Roof Structures* (1873), *Aid Book to Engineering Enterprise*, Pt. 1 (1878), Pt. 2 (1881).

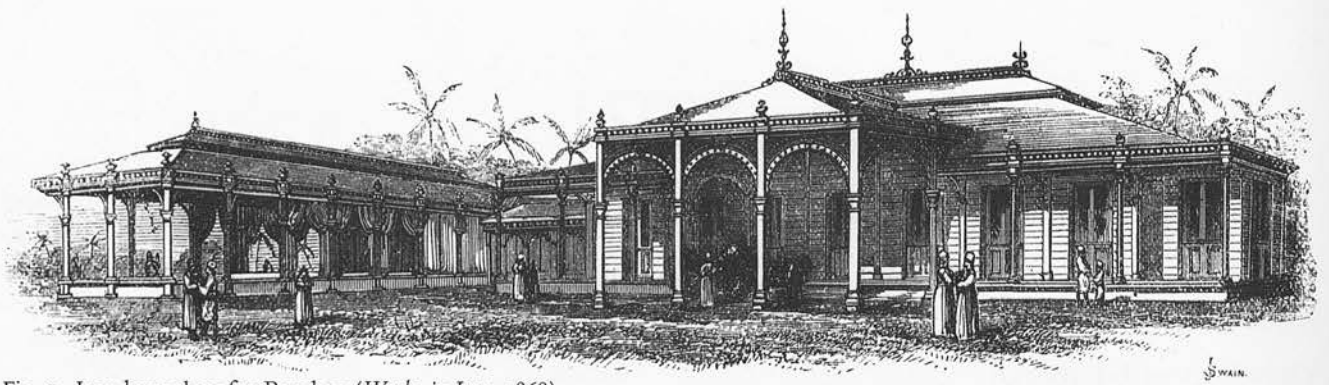


Fig. 1. Iron bungalow for Bombay (*Works in Iron*, 1868).

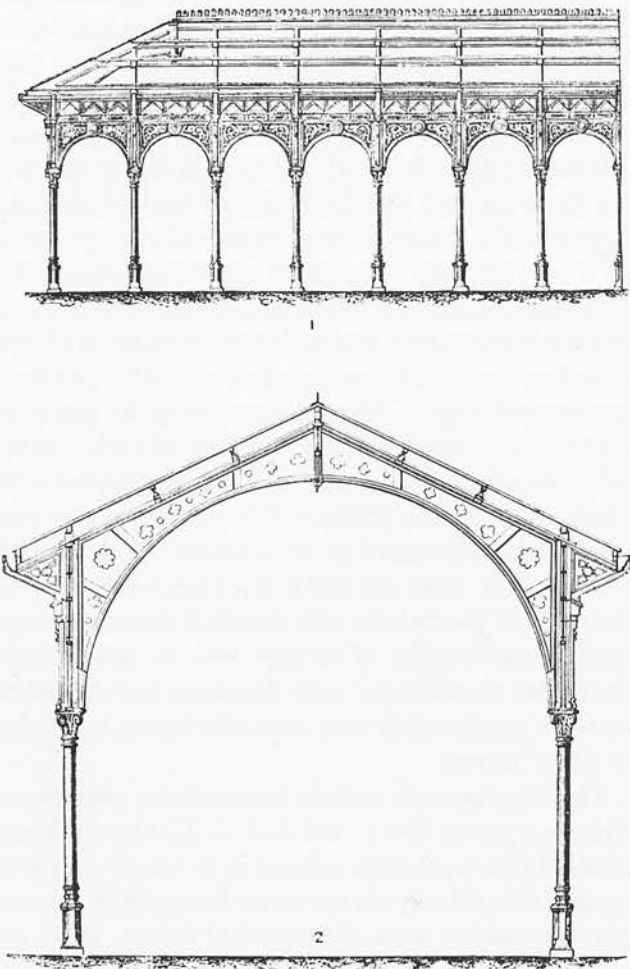


Fig. 2. Kiosk at the Byculla Club, Bombay (*Works in Iron*, 1873).

firm during the 1860s and '70s. Matheson was an engineer with a considerable range of talents. His knowledge of the iron industry was extensive; this can be judged from a paper given before the Society of Engineers in October 1867.<sup>6</sup> He also understood a considerable amount of the economic and practical problems associated with the exportation and erection of iron buildings and bridges. In addition he seems

to have been a man of taste, at least as far as can be judged from his writing.

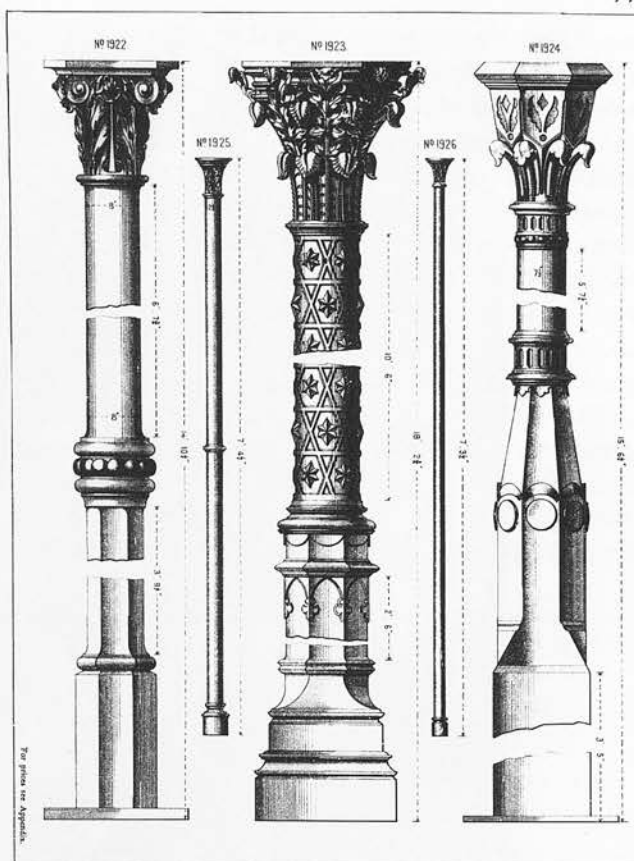
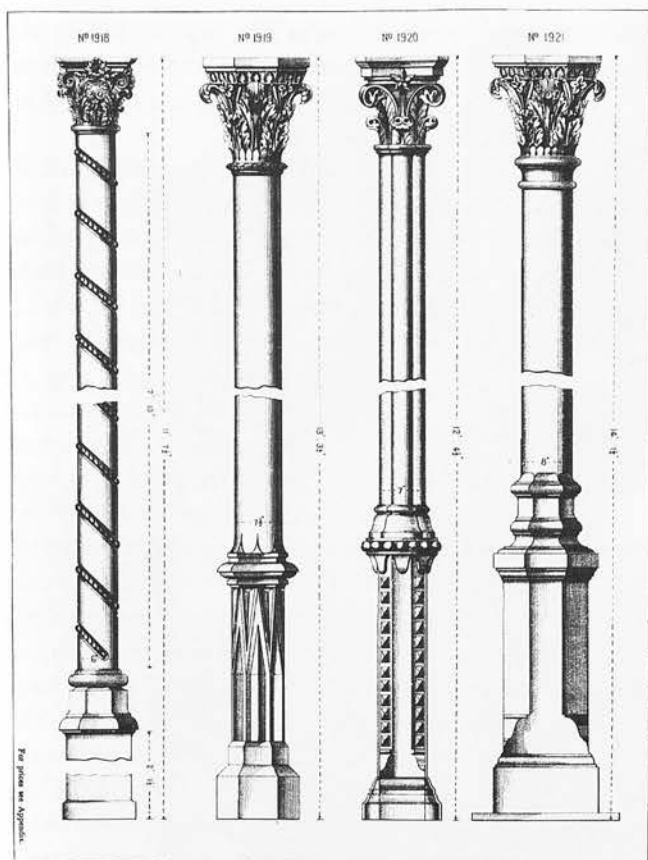
Apart from one design of 1885 produced in collaboration with the engineer, R. M. Ordish, for a bridge on the site of the present Tower Bridge, he can never be said to have designed any structures or buildings. However, the effective execution of many projects was largely due to his efforts, and the establishment of Handyside's as a national and indeed international organization must be acknowledged as largely due to his efforts.

The important work produced by Handyside's during the '60s was first described in detail by the publication in 1868 of *Works of Iron*. Although this could be termed a trade publication, it was handsomely produced by E. & F. N. Spon and sold quite extensively. It was illustrated by many engravings and ten fine photographs (something of a novelty at the time) of Handyside's most accomplished work of the last ten years or so. No author is mentioned but the hand of Ewing Matheson is easily detected when comparison is made with the publication of the same name produced by him five years later. A whole section of the 1868 book is devoted to iron buildings. The illustration of an iron bungalow for India (Fig. 1) taken from this section gives a good idea of the kind of work that Handyside's could undertake. The building is planned on a grid of cast-iron columns eight feet apart, resting on bases of concrete and connected at the top by girders of cast iron forming a gutter and cornice. The walls are fifteen inches thick, consisting of an outside wall of iron plates with an inside boarding, leaving about ten inches space between the wood and iron. This space was sometimes filled with lightweight concrete,<sup>7</sup> principally to prevent the deterioration of the iron where it could not be painted. There was a standard door and window width of 3'6"; the door height of 9'0" allowing a four-foot "venetian" above (apparently omitted in the engraving). The roof, as with the walls, has a double skin, but with a ventilated ridge.

6. *Society of Engineers Transactions* (1867), pp. 168–195.

7. Ewing Matheson, *Aid Book to Engineering Enterprise*, Pt. 2, 436.





The cost of such a building was £2,800 "complete, with woodwork, glass, wall paper and with doors and windows as described, fitted in England, marked for erection and delivered properly packed at any English port."<sup>8</sup> This would make it about 11/- per square foot. The total weight was 120 tons. The cost of shipping such a building was extraordinarily low. It cost more to send a building by rail from Glasgow to London at this time than it did to send the same building from an English port to India or Australia. One of the important reasons for this was that often the general cargo of a ship was so light that shipping companies were only too pleased to accept iron because of its utility as ballast.<sup>9</sup> For this reason the rate could be as low as 10/- per ton. This meant that the transport costs to India of the iron bungalow were only about 2% of the cost of the building.

When the first edition of Matheson's *Works of Iron* was published in 1873, sixty examples of recent major iron structures carried out by Handyside's were described in detail. Many of these were exported buildings, and in the body of the book the author describes all the practical problems associated with the execution of them.

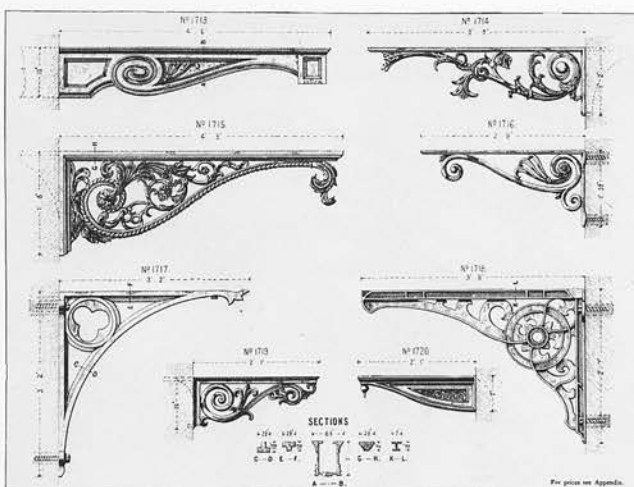


Fig. 3. Pages from Handyside's *Ornamental Ironwork Catalogue* of 1874. No. 1, Columns; No. 2, Columns; No. 3, Cantilevers and Brackets.

The iron building for the Byculla Club, Bombay (Fig. 2) was made in Derby in 1868 and shipped out and erected in the following year. The building was actually ordered by a Parsi during the Share Mania and when he came to grief the Club bought it and erected it as part of the Club build-

8. Handyside, *Works in Iron* (1868), pp. 44-45.

9. Matheson, *Works in Iron* (1873), p. 106.

ing.<sup>10</sup> Here the structure is planned on a 9'0" grid with a span of 27'8". By looking at the pages taken from Handyside's catalogue of 1874<sup>11</sup> (Fig. 3; No. 1) we can pick out the standard column used for this design. However, the building did require a considerable number of new and expensive patterns, most particularly the pierced wrought iron arch members and the ornamental spandrel panels on the long elevation. This of course was reflected in the cost. Here we do not have very exact records but the iron cost about £20 per ton, which is high by comparison with examples which will be described later.

The building for the Nictheroy Gas Works, Rio de Janeiro, 1869 (Fig. 4), employed a standard column and cantilever bracket which can be seen in Figure 3, Nos. 2 and 3. Although a strange choice of rather over-elaborate designs for such a building, the fact that they were standard items

10. Samuel T. Sheppard, *The Byculla Club 1833-1916* (Bombay, 1916), p. 44.

11. *Catalogues B & C, Ornamental Ironwork.*

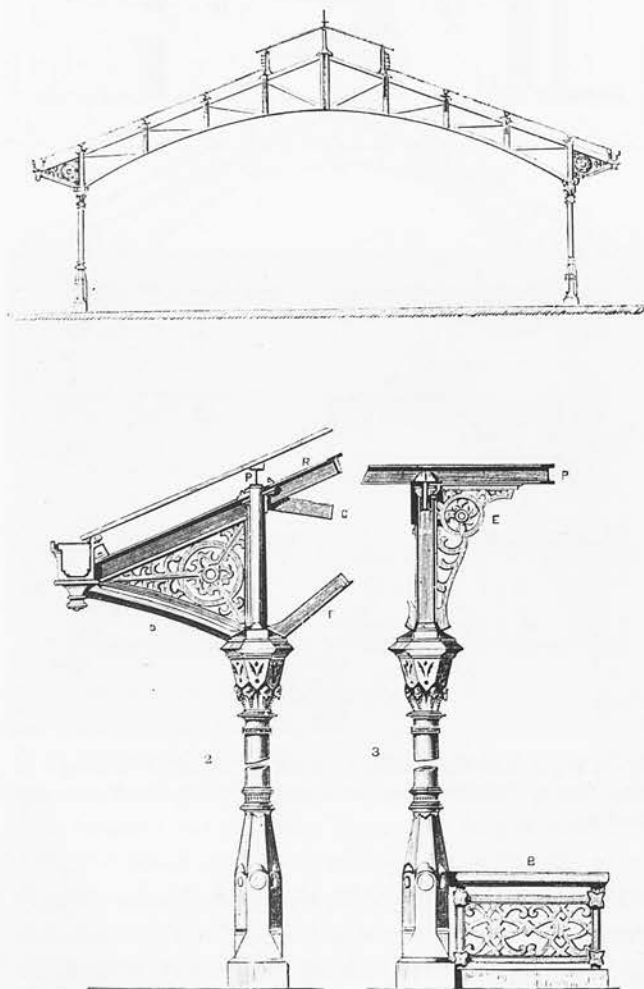


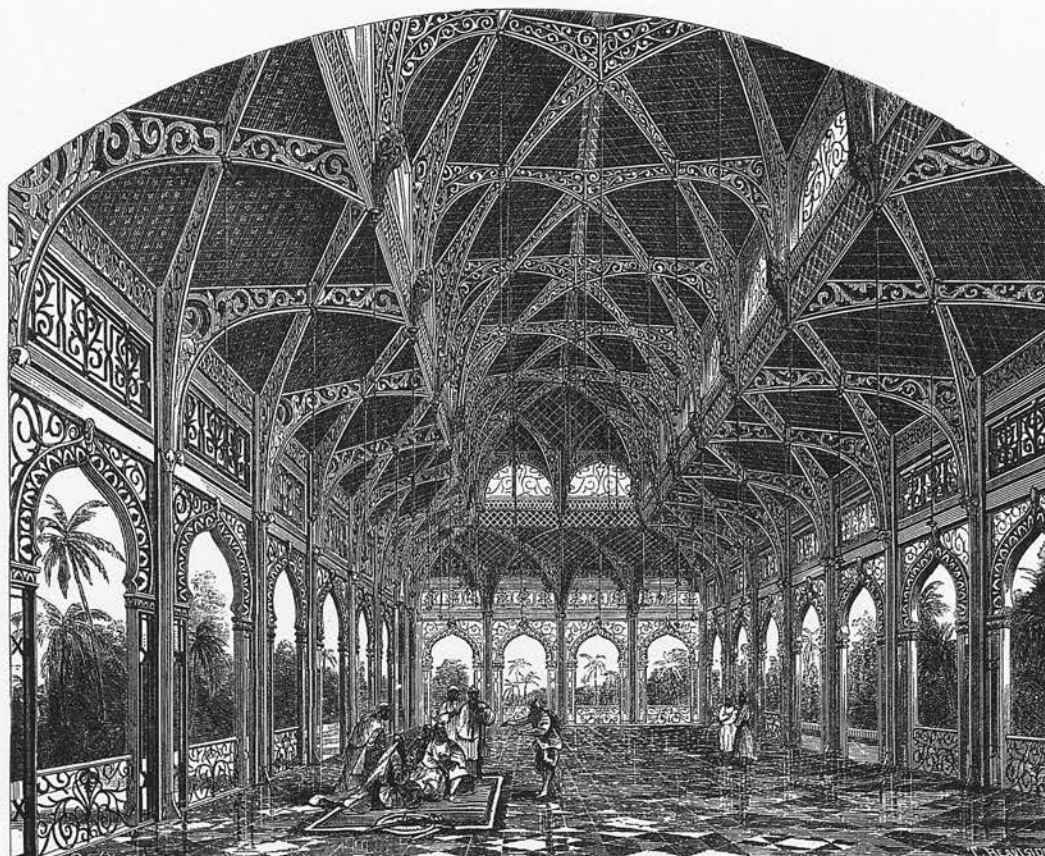
Fig. 4. Iron building for Nictheroy Gas Works, Rio de Janeiro (*Works in Iron*, 1873).

meant that the cost was as low as £12 10/- per ton. In the roof where the construction of cast iron and wrought iron was largely made up of new patterns, the cost rose to £21 per ton.

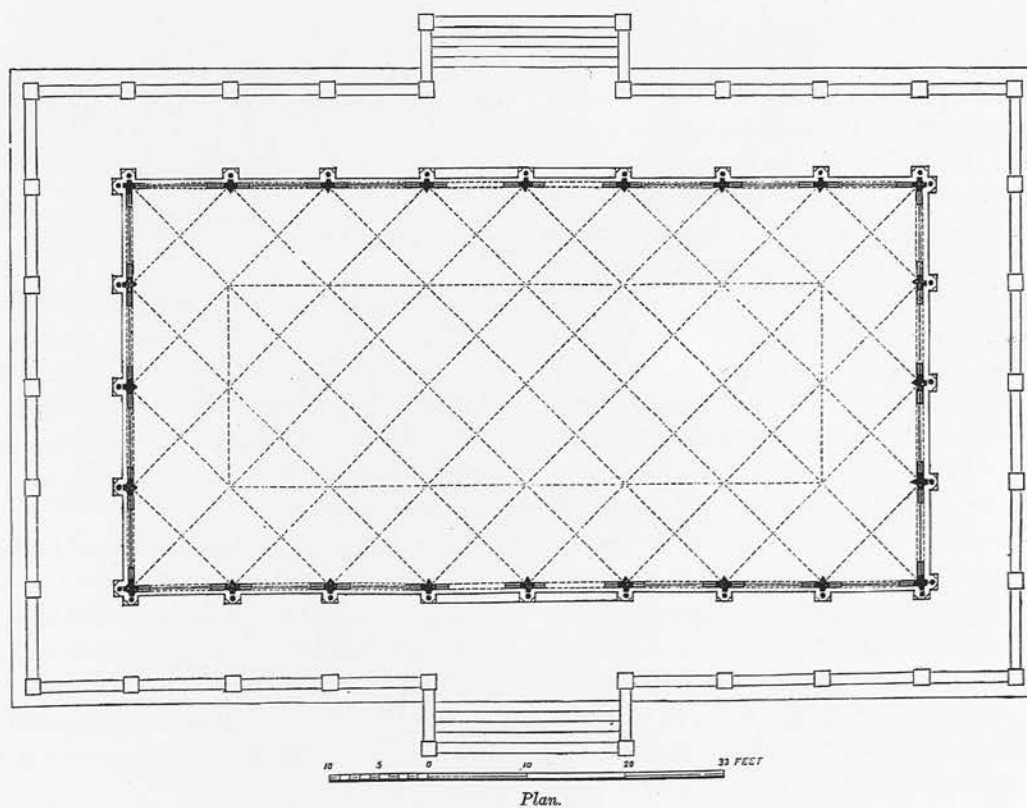
Figures 5 and 6 show perhaps the most remarkable of all Handyside's buildings that are described in *Works of Iron*. It is a kiosk or smoking lounge for Bombay designed by Owen Jones. It is difficult to sort out his contribution from the work of the engineers, R. M. Ordish and W. H. Le Feuvre, and indeed the contribution of Handyside's with their experience of this kind of building. The plan (Fig. 5) shows the way in which the ten-foot grid of columns is arranged to support the diagonal lattice roof. This arrangement gives a standard section through the building in both directions. In order to keep the light appearance of the structure, the transverse stresses from the roof are taken up by hidden girders beneath the floor, which run inwards from the base of the columns. Perhaps the most ingenious structural feature of this building is the way in which the use of bolts in the roof structure has been reduced to a minimum by the device of dovetailing together the joints in the intersecting ribs. The ornamental work is very fine. Figure 7 shows details of the arabesque panels at the side of the building, No. 1 at ground level between columns and No. 2 above the arches. Although there were many new patterns in the building, and £550 was expended on these, the cost of the ironwork still only worked out at £13 10/- per ton. The total cost, including roof and floor finish, was about £3,000.

After being made, presumably in Derby, the building was erected in London on land adjoining the Royal Horticultural Society's Gardens in Exhibition Road, South Kensington. Handyside's had already built the Society's conservatory, at the north end of the Gardens, to Captain Fowke's design in 1860. However, the kiosk almost certainly stood on land that had been recently used for the 1862 Exhibition on the south side of the Gardens. Of course it attracted considerable attention and must have served as a very fine advertisement of Handyside's work. Exactly when it was dismantled and shipped off to India we do not know, nor has it come to light whether it ever reached Bombay.

The general problems of erecting such sophisticated buildings when they arrived at distant colonial territories would have been considerable. There is evidence on the more complicated buildings that in addition to the marking of components mentioned above, a member of Handyside's staff was sent to the site to supervise erection. Obviously accuracy was of the utmost importance, and the general procedure was as follows. Columns were fixed either directly on to bases of brick, stone, or concrete, or on to the



INTERIOR VIEW OF IRON KIOSK.



Plan.

Fig. 5. Plan and interior view of Iron Kiosk for Bombay (*Builder*, 1 Dec. 1866).



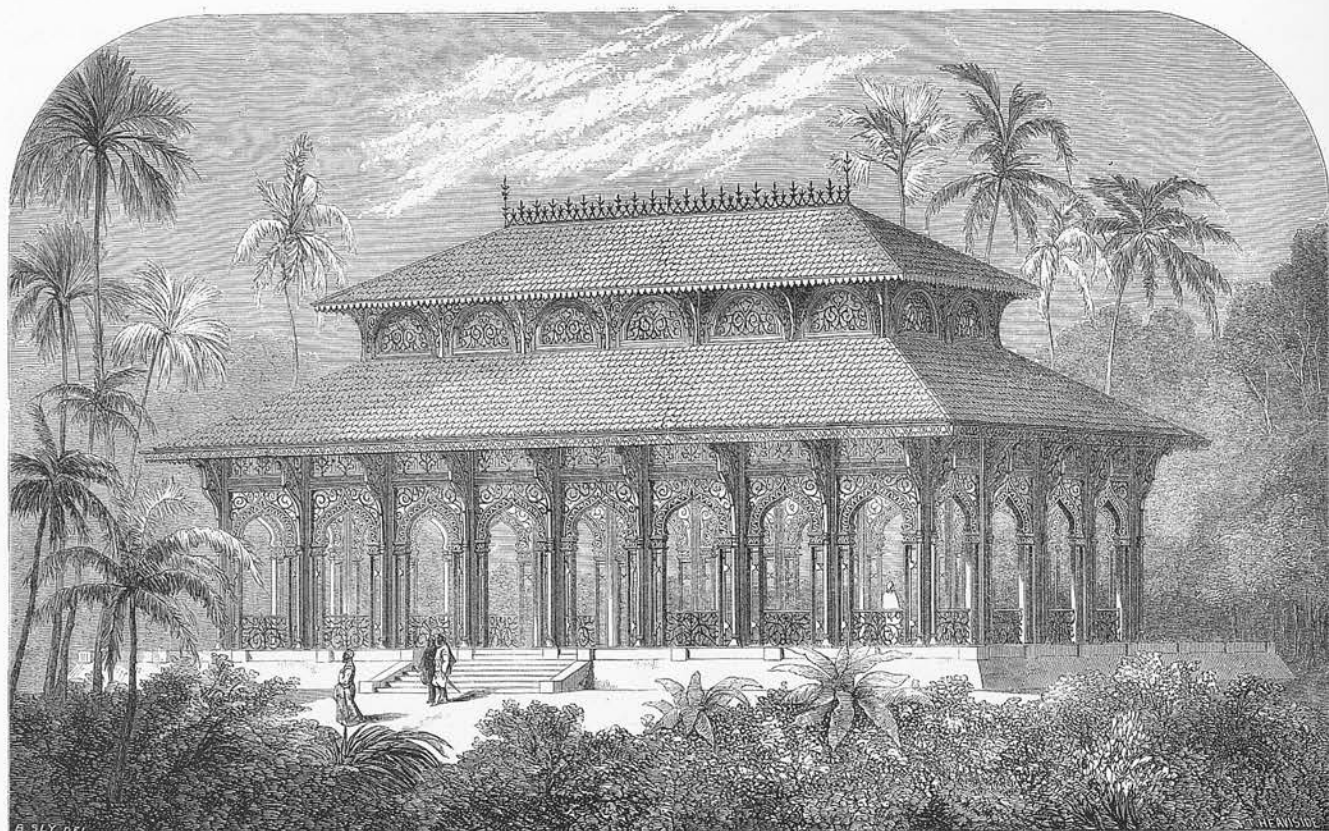


Fig. 6. Exterior view of Iron Kiosk for Bombay (*Builder*, 10 Nov. 1866).

accurately planed upper surface of iron bed plates. The columns were generally erected on their bases with iron wedges underneath so that when all columns were in position they could be aligned accurately by driving in the wedges. The space between the column and base was then caulked with molten lead, iron borings, or Portland cement; the latter being the most common. For most spans the roofs were lifted by a single derrick, a chain sling being attached to the top members of the truss at two points. In order to prevent the roof from being subjected to abnormal strains during this, wooden poles were lashed to the trussed members. Trusses and columns had bolted joints, caulked as previously described to effect a solid rust-proof joint. The cost of erecting such buildings seldom exceeded £4 per ton of ironwork and frequently was achieved at half this figure.

In 1877 a second edition of Matheson's *Works of Iron* was published and contained a further five examples of iron structures, but by now the time when steel was to become an economic alternative was drawing near. The firm did less and less of the type of work described and gradually moved exclusively into the field of engineering structures.

Handyside died in 1887 and at that point Matheson in ad-

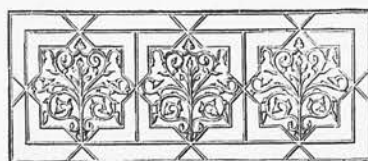


Fig. 7. Cast iron panels, Iron Kiosk for Bombay (*Works in Iron*, 1873). No. 1 and No. 2.

dition to his responsibilities with Handyside's took on the managing directorship of the Farnley Iron Co. Ltd. Matheson finally left Handyside's in 1903. With both Handyside and Matheson gone, the firm lacked a really major figure to carry it along. By 1907 the firm had its maximum payroll but by 1910 it had gone into liquidation, and the next year production stopped.

When we look at the whole history of Handyside's there is no doubt that from an architectural viewpoint the work produced from about 1860 to the early 1880s is of the greatest interest. Here were buildings which from a practical and structural viewpoint were ingenious and inventive, but combined this with a decorative expressiveness which translated the portable building from the province of pedestrian utility to architecture.



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